FEDERAL AVIATION REGULATIONS

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION—WASHINGTON, DC

CHANGE 3 EFFECTIVE: NOVEMBER 2, 1994

Part 29—Airworthiness Standards: Transport Category Rotorcraft

This change incorporates Amendment 29–35, Airworthiness Standards; Crash Resistant Fuel Systems in Normal and Transport Category Rotorcraft, adopted September 26, 1994. This amendment adds new § 29.952 and revises §§ 29.963, 29.967, 29.973, and 29.975.

Bold brackets enclose the most recently changed or added material in these particular sections. The amendment number and effective date of new material appear in bold brackets at the end of each affected section.

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Suggest filing this transmittal at the beginning of the FAR. It will provide a method for determining that all changes have been received as listed in the current edition of AC 00–44, Status of Federal Aviation Regulations, and a check for determining if the FAR contains the proper pages.

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Special Federal Aviation Regulations (SFAR)

costs can be recovered in the market place.

The FAA maintains that, after an engine failure under the revised regulations for limited-use ratings, safety will be at least equivalent to operational safety under the previous regulations. This condition is supported by the fact that these 30-second and 2-minute OEI ratings are "limited use/mandatory inspection ratings." Following one mission cycle of rating use, specific requirements for inspection will have to be met to verify continued airworthiness of the engine. Under current regulations, there is no requirement for an inspection following an OEI power application. Any rotorcraft parts found to be unsuitable for further use must be replaced after application of these ratings. As a result of new test and analysis requirements, a high level of safety will be maintained.

Regulatory Flexibility Determination

The Regulatory Flexibility Act of 1980 (RFA) was enacted by Congress to ensure that small entities are not unnecessarily and disproportionately burdened by government regulations. The RFA requires agencies to review rules that may have "a significant economic impact on a substantial number of small entities." The FAA's criteria for a small aircraft manufacturer is one employing fewer than 75 employees. A substantial number is a number that is not fewer than 11 and is more than one-third of the small entities subject to the rule. A significant impact is one having an annual cost of more than $14,900 (1987 dollars) per manufacturer.

A review of domestic helicopter manufacturing companies indicates that there are fewer than eleven small helicopter manufacturers. Therefore, the amendments to parts 27 and 29 will not affect a substantial number of small entities.

Trade Impact Analysis

The rule changes will have little or no impact on trade for both U.S. firms doing business in foreign countries and foreign firms doing business in the United States. In the U.S. market, foreign manufacturers will have the option of designing engines and helicopters capable of satisfying the new OEI ratings and, therefore, will not be at a competitive disadvantage with U.S. manufacturers. Because of the large U.S. market, foreign manufacturers are likely to certificate their rotorcraft to U.S. rules, which will limit any competitive advantage U.S. manufacturers might gain in foreign markets.

Federalism Implications

The regulations adopted herein will not have substantial direct effects on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government. Therefore, in accordance with Executive Order 12612, it is determined that this final rule does not have sufficient federalism implications to warrant the preparation of a Federalism Assessment.

Conclusion

For the reasons discussed in the preamble, and based on the findings in the Regulatory Flexibility Determination and the Trade Impact Analysis, the FAA has determined that this regulation is not a significant regulatory action under Executive Order 12866. In addition, the FAA certifies that these amendments do not have a significant economic impact, positive or negative, on a substantial number of small entities under the criteria of the Regulatory Flexibility Act. These amendments are considered nonsignificant under DOT Regulatory Policies and procedures (44 FR 11034; February 26, 1979). A regulatory evaluation of the amendments, including a Regulatory Flexibility Determination and Trade Impact Analysis, has been placed in the docket. A copy may be obtained by contacting the person identified under "FOR FURTHER INFORMATION CONTACT."

Airworthiness Standards; Crash Resistant Fuel Systems in Normal and Transport Category Rotorcraft

Adopted: September 26, 1994 **Effective: November 2, 1994**

(Published in 59 FR 50380, October 3, 1994)

SUMMARY: These amendments add comprehensive crash resistant fuel system design and test criteria to the airworthiness standards for normal and transport category rotorcraft. Application of these standards will minimize fuel spillage near ignition sources and potential ignition sources and, therefore, will improve the evacuation time needed for crew and passengers to escape a post-crash fire (PCF). Implementation of these amendments will minimize the PCF hazard saving lives and substantially reducing the severity of physiological injuries sustained from PCF's in otherwise survivable accidents.

FOR FURTHER INFORMATION CONTACT: Mr. Mike Mathias, Regulations Group, (ASW–111), Rotorcraft Directorate, Aircraft Certification Office, FAA, Fort Worth, Texas 76193–0111; telephone (817) 624–5123.

SUPPLEMENTARY INFORMATION:

Background

These amendments are based on a Notice of Proposed Rulemaking (NPRM) No. 90–24, issued September 27, 1990 (55 FR 41000, October 5, 1990). A correction to the NPRM was published on December 11, 1990 (55 FR 50931).

Post-crash fires (PCF's) are the primary cause of fatalities and injuries in otherwise survivable impacts resulting from rotorcraft accidents. It is estimated that 5 percent of the occupants in survivable rotorcraft accidents are killed or injured by PCF's annually. These types of fatalities and traumatic injuries will be substantially reduced by the implementation of the design and test criteria of this amendment. Nearly all PCF's are caused by crash-induced fuel leaks that quickly come in contact with ignition sources during or after impact. The fuel containment and hazard elimination provisions contained in this amendment will, in the majority of cases, give occupants the time necessary to escape a survivable crash before a post-crash fire (PCF) could become life threatening. A crash resistant fuel system (CRFS) would not be expected to prevent all fires; however, a CRFS would, in the majority of survivable accidents, either prevent a PCF or delay the massive fire, or fireball, long enough to allow the occupants to escape. These standards have been validated by military safety statistics as significantly minimizing the PCF hazard and its associated fatalities and injuries.

Discussion of Comments

General

Thirteen commenters, including representatives from small and large U.S. helicopter manufacturers, foreign airworthiness authorities, and foreign helicopter manufacturers, commented on the NPRM. All commenters agree with the FAA that CRFS installations will improve occupant survivability in parts 27 and 29 rotorcraft.

The majority of commenters fully support all of the proposals. No commenter opposes adoption of the proposed amendments. One commenter proposes adoption of more stringent standards, and several commenters offer other counterproposals and recommendations for specific proposals.

Accuracy of the economic analysis

One commenter questions the accuracy of the economic analysis but offers no specific recommendations or corrections. The FAA has reevaluated the analysis and found no changes were necessary based on this comment.

Rigidity of the proposals

A commenter states that the proposed amendments are "too rigid" in their approach and limit the designers' choices. The FAA disagrees. Although the 50-foot drop height and certain strength requirements are specific, these and most of the other requirements do not mandate specific designs. Objective rules allow flexibility in showing compliance. An example of this flexibility is that bladders are not mandated; the rule specifies only freedom from leakage after impact. The amendments are intended to be as flexible as possible to allow design innovation while at the same time requiring a specific safety standard for a CRFS.

Level of detail in the proposals

A commenter states that the amendments include some very detailed requirements that are more appropriate for a Technical Standard Order (TSO). The FAA agrees that some of the details proposed for paragraphs 27.952(e) and (f) and 29.952(e) and (f) should not be regulatory requirements, are more appropriate for an advisory circular, and should not be part of the proposed standard. Therefore, those details have been removed and placed in the draft advisory material. However, the FAA disagrees with the commenter that the level of detail either in the proposals or in the advisory material would necessitate a CRFS TSO.

The standardized approach of the proposals

A commenter believes that the standardized design and test approach of these amendments to CRFS certification, while acceptable, is not as valid as the establishment of individual design criteria on a case-by-case basis followed by a design review and a test program. However, the commenter offered no specific data or case histories to substantiate this position. Since all past successful civil and military experience has been with a standardized design and test approach, the FAA finds no historical or technical basis to support the commenter. Moreover, the FAA has determined that a standardized design and test approach, when properly applied, still allows for adequate use of individual design features that meet the specific safety standards.

Military standards

A commenter expresses concern that the proposals are less stringent than the corresponding military standard because of perceived differences in the military and civil environments. The commenter is especially concerned that fuel tank bladders are not mandated. The commenter proposes verbatim adoption of the military standards. The FAA disagrees. Based on independent studies, the General Aviation Safety Panel (GASP) committee recommendations, and past civil CRFS service experience, the FAA has determined that the proposals, while less stringent than the military standard, provide an equivalent level of safety considering the differences (such as violent atypical flight maneuvers, landing maneuvers, and gunfire hazards) in the civil and military environments. While it is anticipated that most successful fuel cell designs will involve the use of bladders, bladderless rigid designs (that provide the same level of safety as designs with bladders) may be approved under the new standard.

Comment concerning performance criteria specification

One commenter applauds the fact that the proposal specified performance standards (i.e., a minimum level of safety) in lieu of unnecessarily mandating certain specific design features such as flexible liners.

The load factors used for each fuel cell location should be used for fuel cell components of significant mass in the same locations. Therefore, this amendment is adopted as proposed.

Comments on §§ 27.952(a) and 29.952(a)

A commenter states that identification of a critical fuel tank (if such exists) should not be allowed in certification. The FAA does not agree. The use of critical conditions, systems, etc., is a well-established technique for substantiating similar design features. Therefore, these amendments are adopted as proposed.

Comments on §§ 27.952(a)(1) and 29.952(a)(1)

All commenters support the proposed drop test, and most commenters favor the 50-foot drop height. However, two commenters propose a reduction in the drop height for a bare fuel cell from 50 to 25 feet. Another commenter proposed a reduction in drop height of a fuel cell test article configuration (i.e., a fuel cell installed in its representative airframe structure) from 50 to 15 feet. Another commenter contends that since the military fuel cell drop test (and nearly 20 years of associated, successful safety experience) is at a 65-foot drop height, the proposed drop height should be 65 feet, not 50 feet. The proposed 50-foot drop height is based, in part, on an analysis of nearly 20 years of combined military and civilian design and operational data. (The 15-foot reduction in drop height from the military standard to the proposed civil standard equates their level of safety because of the elimination of the additional risks associated with the military environment.) A significant part of this 20 years of data is based on approximately 1,500 civil rotorcraft that have been certificated (on a voluntary, nonhazard basis) to design standards (including a 50-foot drop test) analogous to these proposals. This 20 years of data and experience (from both the military and voluntary civil unit installations) have resulted in a good operational safety record. This good safety record indicates that fuel tank installations designed to these proposals (including the practical standard of a 50-foot drop height) successfully minimize the post-crash fire hazard. Therefore, no change to the 50-foot drop height is warranted.

Another commenter proposes deletion of the requirement to drop the fuel cell in its surrounding structure. The same commenter asks if the bare tank drop test will follow the procedure of MIL–T–27422B when the surrounding structure is free of projections or design features likely to contribute to tank ruptures. Another commenter states that the requirement to drop a representative structure should be fully defined. The same commenter states that no mention is made of production drop test requirements that would be made necessary by postproduction design changes to either the fuel system or its surrounding structure. The FAA considers these suggested changes unnecessary because (under part 21) a design review (precipitated by a proposed design modification that affects the fuel cell-airframe interface) would automatically require a review of the interface with regard to these proposed standards. If that design review shows the surrounding structure is free of projections and hazards, the fuel cell may be dropped alone. Additionally, MIL–T–274228 procedures may be used, except that the drop height is reduced to 50 feet. Further, major post certification design changes, such as major changes to the fuel system cells or their locations, automatically require recertification in accordance with FAR 21.93(a). Therefore, the amendments are adopted as proposed.

Comments on §§ 27.952(a)(3) and 29.952(a)(3)

A commenter notes that the proposed drop test criteria require that the fuel cell test article be filled 80 percent with water with no mention of the contents of the other 20 percent. The commenter states that this is different from part 23 Notice No. 85–7A (55 FR 7280, February 28, 1990) in that the proposed rotorcraft amendments do not require the air to be removed from the fuel cell prior to the drop test. The commenter suggests that the best method of compensating for the difference between the density of fuel and water is to leave the tank 100 percent full of fuel and adjust the drop height to a lower value.

The FAA notes that the drop test criteria proposed in Notice 90–24 are the same as those proposed in part 23 Notice 85–7A and the same as those used to comply with MIL–T–27422B. There are standard, by the industry.

The method chosen to compensate for the density of water versus that of fuel (i.e., 80 percent full of water) is a standard method. It is used successfully by the civil rotorcraft industry. The commenter's alternate method of reducing the drop height has some merit but is not supported by current, known data.

Therefore, these amendments are adopted as proposed.

Comments on §§ 27.952(a)(4) and 29.952(a)(4)

A commenter notes that the amendments differ from MIL–T–27422B, in that the amendments require that the tank be dropped in its surrounding structure, unless it is clearly shown that the structure is free from projections and other such hazards. The commenter suggests that the FAA not adopt the requirement to drop the tank in the surrounding structure. The FAA disagrees. The FAA concluded that in the interests of safety the tank should be dropped in its surrounding structure. Only when all projections and-other puncture hazards have been minimized by design will dropping a bare fuel cell suffice to show compliance. The FAA's approach improves on the MIL–T–27422B criteria in that an FAA-approved, documented certification design review will be required to minimize the surrounding airframe projections and other puncture hazards prior to a bare tank drop test. Therefore, the amendments are adopted as proposed.

Comments on §§ 27.952(b) and 29.952(b)

A commenter states that the load factors proposed in these sections are redundant to those contained in structural §§ 27.561 and 29.561(d), that no procedures to conduct these tests have been defined, and that the cost of this type of testing is not addressed. Two other commenters question the need for specification of separate load factors by rotorcraft zone (i.e., location) for fuel cells that exceed the standard airframe load factors. The FAA disagrees that the proposed load factors are redundant. They are for fuel cells and major mass items in the fuel system only. The load factors are to be used in standard structural analysis to structurally design the fuel cells, other major fuel system mass items, and their attachments. No special tests, other than the required structural substantiation tests are intended. No costs have been added since the required structural analysis and test programs are already conducted during certification for these components to the current load factors The separate load factor specification by zone is necessary to provide proper crash resistance for occupant safety and PCF prevention for fuel system components located in three selected zones of the rotorcraft. They also provide the designer with specific criteria (i.e., load factors) for proper static analysis of fuel system components in these specific zones. The load factors proposed by §§ 27.952(b) and 29.952(b) are for fuel system components only; whereas, the load factors of current § 29.561(d) are for the airframe only. However, load factors for fuel system components and airframe components are compatible.

Therefore, the amendments are adopted as proposed.

Comments on §§ 27.952(b)(2) and 29.952(b)(2)

A commenter suggests that the words ". . . that if loosened could injure an occupant in an emergency landing. . . ." be removed from §§ 27.952(b)(2) and 29.952(b)(2). The commenter believes removal to be necessary because this phrase is intended to minimize a "mechanical" ballistic hazard from fuel system components and not a PCF hazard. The amendments, in the commenter's view, are only intended to minimize a PCF. The commenter's presumption is incorrect. The amendments are intended to provide a CRFS. This includes preventing impact-induced, ballistic hazards to fuel system components as well as PCF hazards. Therefore, the amendments are adopted as proposed.

Comments on §§ 27.952(c) and 29.952(c)

A commenter believes that the proposed amendments mandate self-sealing breakaway couplings and suggests that the amendments be revised to include the words "Where hazardous relative motion of

Comments on §§ 27.952(c)(1)(iii) and 29.952(c)(1)(iii)

A commenter suggests that §§ 27.952(c)(1)(iii) and 29.952(c)(1)(iii) be changed to specify leakage as one method of detecting an unlocked or otherwise faulty breakaway coupling. The FAA agrees that leakage is one method of detecting an unlocked coupling but finds that the proposed wording of "design provisions to visually ascertain" adequately covers consideration of leakage as a means to verify locking of the couplings. Therefore, the amendments are adopted as proposed.

Comments on §§ 27.952(c)(1)(v) and 29.952(c)(1)(v)

A commenter suggests that §§ 27.952(c)(1)(v) and 29.952(c)(1)(v) be changed to allow "fuel seepage" after a breakaway coupling has performed its intended function. The FAA agrees with the intent of the comment but has determined that this kind of detail is more appropriate in advisory guidance material. It is intended that industry practice, which allows loss of entrapped fuel (up to 8 ounces) and fuel seepage (up to 5 drops per minute), be acceptable after the valve has functioned. Therefore, the amendments are adopted as proposed.

Comments on §§ 27.952(d) and 29.952(d)

A commenter suggests adding a sentence between the second and third sentences of §§ 27.952(d) and 29.952(d) as follows: "For tanks using a flexible tank or flexible liner, all filler caps and tank fittings attached to structure in locations of anticipated structural deformation must be frangibly attached such that the tank fittings and filler caps stay with the fuel tank to preclude tank ruptures after the frangible separation." The FAA agrees with the intent of this comment but finds that no change is necessary in the final rule. The FAA understands the commenter is suggesting that compliance methodology rather than objective substance be included in the rule. Therefore, the amendments are adopted as proposed.

Comments on §§ 27.952(d)(1) and 29.952(d)(1)

A commenter suggests that the FAA remove the second sentence from §§ 27.952(d)(1) and 29.952(d)(1), which reads as follows: "To prevent inadvertent separation or deformation, the load must be 10 times the normal service loads at the frangible or deformable attachment location." The FAA recognizes the large variance in industry design practice in calculating this particular ratio and in setting its specific value. Accordingly, the FAA agrees with the commenter, and the sentence is removed from the final rule. Therefore, these amendments are adopted as revised.

Comments on §§ 27.952(e)(1) and 29.952(e)(1)

A commenter states that the proposed §§ 27.952(e)(1) and 29.952(e)(1) criteria largely repeat existing criteria. The commenter provides several specific examples of the perceived repetition. Another commenter asks why airframe mounted fuel filters are not acceptable in the engine compartment (i.e., fire zone) if engine mounted filters are acceptable. The FAA maintains that the proposed sections relate to a post-crash configured rotorcraft, that is radically different in terms of ignition sources, fuel leaks, and geometry than a pre-crash configured rotorcraft even though similarities may exist. Prior to these proposed amendments, parts 27 and 29 applied only to pre-crash (or flight) configured rotorcraft. Also, the proposed sections refer to the entire rotorcraft, not just specific zones, such as the pre-crash configured exhaust system regulations that were cited by the commenter in a particular example. However, because of this and other related comments, the FAA has decided to simplify the final rule by deleting the proposed subsections relating to compliance methodology and moving the term "occupiable areas" from proposed paragraphs e(4) to revised paragraphs (e).

With respect to the comment concerning the use of airframe mounted fuel filters, the FAA agrees that airframe mounted fuel filters, as well as engine mounted fuel filters inside the engine fire zone, are acceptable. Therefore, §§ 27.952(e) and 29.952(e) are adopted as revised; and §§ 27.952(e)(1), (e)(2), (e)(3), (e)(4); 29.952(e)(1), (e)(2), (e)(3) and (e)(4) are deleted.

fuel cell. Such a design decision would not need to be considered under the current standards. Under these proposals it would have to be considered. As stated previously, §§ 27.952(e)(4) and 29.952(e)(4) have been removed in order to simplify the final rule by deleting the compliance methodology. However, the requirement for separation of fuel tanks from occupiable areas is adopted in §§ 27.952(e) and 29.952(e).

Comments on §§ 27.952(e) and 29.952(e)(5)

Three commenters correctly observe that §§ 27.952(e)(5) and 29.952(e)(5) contained the incorrect reference, ". . . (as defined by paragraph (b) of this section). . . ." The FAA agrees. As stated previously, §§ 27.952(e)(5) and 29.952(e)(5) have been removed in order to simplify the final rule by deleting the compliance methodology.

Comments on §§ 27.952(e)(6) and 29.952(e)(6)

A commenter states that, under his interpretation, proposed §§ 27.952(e)(6) and 29.952(e)(6) would require firewalls to retain their sealing ability under the load factors of §§ 27.952(b)(1) and 29.952(b)(1). The commenter believes that all large mass items, such as engines and cowlings, in the vicinity of the firewall would have to be restrained to prevent impact-induced firewall ruptures (i.e., preserve postimpact sealing ability). The commenter further believes that, based on other common design requirements such as fuel line penetrations of firewalls, the proposed amendment is impractical. Another commenter concurs with the proposed firewall survivable impact sealing retention requirement, but is concerned that a direct application of the proposed §§ 27.952(b)(1) and 29.952(b)(1) load factors would produce a stiff, heavy firewall that, while able to retain sealing capability, would be heavy, uneconomical, and not have the intended crash-resistant design features.

The commenters misinterpreted the intent of proposed §§ 27.952(e)(6) and 29.952(e)(6). These proposals are based on similar MIL–STD–1290 requirements that have been used in design for many years. The FAA does not intend that a firewall designed to the load factors of §§ 27.952(b)(1) and 29.952(b)(1) would retain its complete sealing ability under all post-crash threats. Thus, some leakage around typical vent and line penetrations and other small post-crash penetrations of the firewall in a survivable impact are acceptable. Unless an obvious, catastrophic hazard would be created in a survivable impact by atypical design features, restraint of the engines and cowling to prevent impact-induced firewall rupture was not intended. The FAA intends that the firewall retain its sealing ability in a survivable impact. The most significant problem addressed during the firewall design is deformation of the firewall induced by fuselage deformations under crash conditions.

Concerning the second comment, the FAA does not agree that the proposed requirement will result in stiff, heavy firewalls. The requirement can be met by a firewall of a low stiffness, ductile design that can withstand the maximum vertical, lateral, and horizontal crushing displacements that are estimated to occur in a survivable impact. A low stiffness, ductile design can efficiently accommodate crash-induced deformations without shearing fuel or electrical lines and without rupturing or otherwise losing its gross sealing ability (i.e., creating a major ignition source or fire path). A displacement based firewall certification test should be conducted that shows that it is capable of performing its intended gross sealing function in a survivable impact. As stated previously, in order to simplify the final rule by deleting the compliance methodology, new §§ 27.952(e) and 29.952(e) are adopted as revised, and proposed §§ 27.952(e)(6) and 29.952(e)(6) are removed.

Comments on § 27.952(e)(1)(iv) and 29.952(e)(1)(iv)

A commenter suggests that §§ 27.952(e)(1)(iv) and 29.952(e)(1)(iv) be modified to add the phrase ". . . if it can be considered an ignition source," to the end of the last sentence. The commenter correctly states that not all hot surfaces should be considered as ignition sources. The FAA agrees. As stated previously, §§ 27.952(e)(1)(iv) and 29.952(e)(1)(iv) have been removed; new §§ 27.952(e) and 29.952(e) adequately incorporate the substance of this comment.

FAR requirements and several other sections of 27.952 and 29.952. The commenter cited several examples of perceived duplication. The FAA agrees with the first commenter's proposal to place detailed design criteria in the advisory circular material. Therefore, proposed §§ 27.952(f)(1) through 27.952(f)(9) and 29.952(f)(1) through 29.952(f)(9) are removed. Sections 27.952(f) and 29.952(f) are revised to replace the proposed, detailed design criteria specified after the phrase "as follows:" with a less detailed design criteria indicated by the phrase, ". . . to be crash resistant. . . ." Therefore, these amendments are adopted as revised. Additionally, this revision answers the second commenter's perceived duplicity concerns.

Another commenter notes that the word "long" used in line 4 of § 29.952(f)(5) should be "along". The FAA agrees but no correction is necessary since this proposed paragraph was removed.

Comments on §§ 27.952(g) and 29.952(g)

A commenter suggests that requirements for impact and tear resistance be included in the amendments. The commenter correctly notes that the GASP report recommends specific impact and tear resistance values for civil rotorcraft based on MIL–T–27422B requirements. The FAA agrees with the comment in general but notes that proposed §§ 27.952(g) and 29.952(g) objectively requires that crash-resistant fuel cells be tear and impact resistant. Further, it is intended that paragraphs 4.6.5.1 through 4.6.5.5 of MIL–T–27422B (modified for the civil environment) may be used to provide one acceptable method of properly assessing impact and tear resistance. Therefore, the amendments are adopted as proposed.

Comments on §§ 27.952(h) and 29.952(h)

Two commenters state that §§ 27.952(h) and 29.952(h) and (b) are redundant. The FAA agrees. Therefore, proposed §§ 27.952(h) and 29.952(h) are deleted.

Comments on §§ 27.975(b) and 29.975(a)(7)

A commenter states full support for §§ 27.975(b) and 29.975(a)(7), which propose that the venting system be designed to minimize spillage of fuel through the vents to an ignition source in the event of a rollover. However, the comment suggests deletion of the phrase ". . . is shown to be extremely improbable . . ." because, in his view, in practical terms, it would be impossible for an applicant to demonstrate such a low probability. The FAA agrees. The current term "extremely remote" rather than "extremely improbable" was intended. The FAA has determined that "extremely remote" is the correct term. The amendments are adopted as proposed except for replacing the word "improbable" with the word " remote."

Regulatory Evaluation Summary

Executive Order 12866 dated September 30, 1993, directs Federal agencies to promulgate new regulations and maintain current regulations only if they are required by law, are necessary to interpret the law, or are made necessary by a "compelling public need." The order also requires that agencies assess all costs and benefits of available regulatory alternatives and select the alternative that maximizes the net benefits and imposes the least burden on society.

Additionally, the order requires agencies to submit a list of all rules, except those specifically exempted by the Office of Information and Regulatory Affairs (OIRA) because they respond to emergency situations or other narrowly defined exigencies, to determine if the rules constitute "significant regulatory action." "Significant regulatory action" means an action that is likely to result in a rule that may (1) have an annual effect on the economy of $100 million or more or adversely affect in a material way the economy, a sector of the economy, productivity, competition, jobs, the environment, public health or safety, or state, local, or tribal governments or communities; (2) create a serious inconsistency or otherwise interfere with an action taken or planned by another agency; (3) materially alter the budgetary impact of entitlements, grants, user fees, or loan programs or the rights and obligations of recipients thereof; or (4) raise novel legal or policy issues arising out of legal mandates, the President's priorities, or crashworthiness dynamics, the FAA found that burn fatalities and injuries account for about 14 percent of rotorcraft accident casualties and occur in about 20 percent of the accidents in which there are injuries. In a study comparing rotorcraft equipped with and without a CRFS, the U.S. Army found that average thermal casualty costs per survivable accident were 95.4 percent lower in CRFS-equipped rotorcraft, and that 50 percent of all rotorcraft accidents with a PCF are survivable prior to the onset of fire. An FAA review of NTSB rotorcraft accident data from 1983 through 1987 shows that 295 accidents occurred that involved a crash landing or collision with an object resulting in fatalities, serious injuries, or combinations of fatalities and injuries. Sixty-three of these accidents involved a PCF, in which about 77 percent of the occupants were fatally injured, as compared to 42 percent of the occupants in accidents not involving a PCF.

In the 63 accidents involving a PCF, there were 113 fatalities, 27 serious injuries, 5 minor injuries, and one noninjury. The FAA estimates that the use of CRFS's would have altered these casualty distributions to approximately the following: 83 fatalities, 31 serious injuries, 24 minor injuries, and 8 noninjuries—a difference of 30 fewer fatalities with some of the fatalities being reduced to serious injuries (4) and minor injuries (19).

In order to provide the public and government officials with a benchmark comparison of the expected safety benefits of rulemaking actions with estimated costs over an extended period of time, the FAA currently uses a minimum value of $1.5 million to statistically represent an avoided fatality. Serious injuries are estimated to have an average cost of $640,000, and minor injuries are estimated to have an average cost of $2,300. Applying these values to the calculated differences yields benefits of about $42 million [(30 fewer fatalities × $1.5 million) − (4 more serious injuries × $640,000) − (19 more minor injuries × 2,300)]. The average benefit per accident involving a PCF is approximately $670,000. Accounting for parts 27 and 29 separately, the average benefits are approximately $464,000 per part 27 rotorcraft accident involving a PCF and approximately $1,638,000 per part 29 rotorcraft accident involving a PCF.

During the 5-year study period, an average of 5,450 part 27 rotorcraft and an average of 1,150 part 29 rotorcraft were in operation in the United States. During this period, the annual probability of a part 27 rotorcraft being involved in a serious survivable accident with a PCF is estimated to be 1.908×10^{-3} ((52 accidents / 5,450 part 27 rotorcraft) / 5 years). The corresponding probability for part 29 rotorcraft is 1.913×10^{-3} ((11 accidents / 1,150 part 29 rotorcraft) / 5 years). Multiplying these probabilities by the estimated benefits per accident with a PCF yields annual benefits of $885 per part 27 rotorcraft and $3,134 per part 29 rotorcraft. Assuming 15-year operating lives, these benefits when discounted equate to $3,103 per part 27 rotorcraft and $10,985 per part 29 rotorcraft.

Costs

This rule will increase costs for both rotorcraft manufacturers and operators. Manufacturers will incur increased development, certification, and production costs; and operators (in addition to absorbing these costs in higher rotorcraft acquisition costs) will incur increased operating costs due to the additional weight of the fuel system.

The FAA estimates the development and certification costs per new rotorcraft certification will be $36,000. Most of these costs are for testing, analysis, and documentation. The primary testing required by the rule is a test of each fuel tank to show no loss of fuel under specified crash conditions. This can be accomplished by a simple, inexpensive drop test.

There will be increased production costs associated with fuel tanks, fittings, and flexible fuel lines. The incremental cost of a fuel tank meeting the requirements of the rule is estimated to be $30 per gallon of tank capacity. Part 27 rotorcraft are assumed to have 50-gallon tanks that will cost $1,500 more as a result of this rule; part 29 rotorcraft are assumed to have 200-gallon tanks costing $6,000 more. The FAA estimates that the cost per frangible, self-sealing fitting is $60; that a typical part 27 rotorcraft will require 8 fittings, totaling $480; and that a typical part 29 rotorcraft will require 10

Assuming 15-year operating lives, the total incremental development, certification, production, and operating costs when discounted are $1,426 per part 27 rotorcraft and $4,617 per part 29 rotorcraft.

Benefit/Costs Comparison

Benefits exceed costs for both parts 27 and 29 rotorcraft. The net present value (discounted benefits minus discounted costs) is $1,677 per part 27 rotorcraft and $6,368 per part 29 rotorcraft. The rule will be cost beneficial even if it is only 50 percent effective in eliminating PCF fatalities and injuries.

Regulatory Flexibility Determination

The Regulatory Flexibility Act (RFA) of 1980 was enacted by Congress to ensure that small entities are not unnecessarily or disproportionately burdened by Government regulations. The RFA requires a Regulatory Flexibility Analysis if a rule is expected to have a "significant economic impact on a substantial number of small entities." FAA Order 2100.14A, Regulatory Flexibility Criteria and Guidance, prescribes standards for complying with RFA review requirements in FAA rulemaking actions. The FAA does not expect the rule to have a significant economic impact on a substantial number of small manufacturers or operators.

Trade Impact Assessment

The rule will have no impact on trade for either U.S. firms doing business in foreign markets or foreign firms doing business in the United States. In the United States, foreign manufacturers must meet U.S. requirements, and thus will gain no competitive advantage. In foreign countries, U.S. manufacturers are not bound by parts 27 and 29 requirements and can choose whether or not to implement the provisions of this rule on the basis of competitive and other considerations. Also, the Joint Airworthiness Authority (JAA) and Transport Canada are both in the process of adopting this rule.

Federalism Implications

The regulations herein do not have substantial direct effects on the states, on the relationship between the national government and the states, or on the distribution of power and responsibilities among the various levels of government. Therefore, in accordance with Executive Order 12612, it is determined that this amendment does not have sufficient federalism implications to warrant the preparation of a Federalism Assessment.

Conclusion

For the reasons discussed in the preamble and based on the findings in the Regulatory Flexibility Determination and the Trade Impact Assessment, the FAA has determined that these amendments are not major under Executive Order 12866. In addition, the FAA certifies that these amendments do not have a significant economic impact, positive or negative, on a substantial number of small entities under the criteria of the Regulatory Flexibility Act. These amendments are considered nonsignificant under DOT Regulatory Policies and Procedures (44 FR 11034; February 26, 1979). A regulatory evaluation of the amendments, including a Regulatory Determination and Trade Impact Analysis, has been placed in the docket. A copy may be obtained by contacting the Rules Docket (AGC–10), Docket No. 26392, 800 Independence Avenue, SW., Washington, DC 25890.

The Amendment

Accordingly, the Federal Aviation Administration amends 14 CFR parts 27 and 29 of the Federal Aviation Regulations effective November 2, 1994.

The authority citation for part 29 continues to read as follows:

Ch. 3

§ 29.901 Installation.

(a) For the purpose of this part, the powerplant installation includes each part of the rotorcraft (other than the main and auxiliary rotor structures) that—

(1) Is necessary for propulsion;

(2) Affects the control of the major propulsive units; or

(3) Affects the safety of the major propulsive units between normal inspections or overhauls.

(b) For each powerplant installation—

(1) The installation must comply with—

(i) The installation instructions provided under § 33.5 of this chapter; and

(ii) The applicable provisions of this subpart.

(2) Each component of the installation must be constructed, arranged, and installed to ensure its continued safe operation between normal inspections or overhauls for the range of temperature and altitude for which approval is requested.

(3) Accessibility must be provided to allow any inspection and maintenance necessary for continued airworthiness;

(4) Electrical interconnections must be provided to prevent differences of potential between major components of the installation and the rest of the rotorcraft; and

(5) Axial and radial expansion of turbine engines may not affect the safety of the installation.

(6) Design precautions must be taken to minimize the possibility of incorrect assembly of components and equipment essential to safe operation of the rotorcraft, except where operation with the incorrect assembly can be shown to be extremely improbable.

(c) For each powerplant and auxiliary power unit installation, it must be established that no single failure or malfunction or probable combination of failures will jeopardize the safe operation of the rotorcraft except that—

(1) The failure of structural elements need not be considered if the probability of any such failure is extremely remote; and

(2) The failure of engine rotor discs need not be considered.

(d) Each auxiliary power unit installation must meet the applicable provisions of this subpart.

[(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–13, Eff. 5/2/77); (Amdt. 29–17, Eff. 12/1/78); (Amdt. 29–26, Eff. 10/3/88)]

§ 29.903 Engines.

(a) *Engine type certification.* Each engine must have an approved type certificate. Reciprocating engines for use in helicopters must be qualified in accordance with § 33.49(d) of this chapter or be otherwise approved for the intended usage.

(b) *Category A: Engine isolation.* For each category A rotorcraft, the powerplants must be arranged and isolated from each other to allow operation, in at least one configuration, so that the failure or malfunction of any engine, or the failure of any system that can affect any engine, will not—

(1) Prevent the continued safe operation of the remaining engines; or

(2) Require immediate action, other than normal pilot action with primary flight controls, by any crewmember to maintain safe operation.

(c) *Category A: Control of engine rotation.* For each category A rotorcraft, there must be a means for stopping the rotation of any engine individually in flight, except that, for turbine engine installations, the means for stopping the engine need be provided only where necessary for safety. In addition—

(1) Each component of the engine stopping system that is located on the engine side of the firewall, and that might be exposed to fire, must be at least fire resistant; or

(2) Duplicate means must be available for stopping the engine and the controls must be where all are not likely to be damaged at the same time in case of fire.

(d) *Turbine engine installation.* For turbine engine installations, the powerplant systems associengines, engine restart capability must be demonstrated throughout a flight envelope for the rotorcraft.

(3) Following the in-flight shutdown of all engines, in-flight engine restart capability must be provided.

[(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–12, Eff. 2/1/77); (Amdt. 29–13, Eff. 5/2/77); (Amdt. 29–22, Eff. 3/26/84); (Amdt. 29–26, Eff. 10/3/88); (Amdt. 29–31, Eff. 10/22/90)]

§ 29.907 Engine vibration.

(a) Each engine must be installed to prevent the harmful vibration of any part of the engine or rotorcraft.

(b) The addition of the rotor and the rotor drive system to the engine may not subject the principal rotating parts of the engine to excessive vibration stresses. This must be shown by a vibration investigation.

§ 29.908 Cooling fans.

For cooling fans that are a part of a powerplant installation the following apply:

(a) *Category A.* For cooling fans installed in Category A rotorcraft, it must be shown that a fan blade failure will not prevent continued safe flight either because of damage caused by the failed blade or loss of cooling air.

(b) *Category B.* For cooling fans installed in category B rotorcraft, there must be means to protect the rotorcraft and allow a safe landing if a fan blade fails. It must be shown that—

(1) The fan blade would be contained in the case of a failure;

(2) Each fan is located so that a fan blade failure will not jeopardize safety; or

(3) Each fan blade can withstand an ultimate load of 1.5 times the centrifugal force expected in service, limited by either—

(i) The highest rotational speeds achievable under uncontrolled conditions; or

(ii) An overspeed limiting device.

§ 29.917 Design.

(a) *General.* The rotor drive system includes any part necessary to transmit power from the engines to the rotor hubs. This includes gear boxes, shafting, universal joints, couplings, rotor brake assemblies, clutches, supporting bearings for shafting, any attendant accessory pads or drives, and any cooling fans that are a part of, attached to, or mounted on the rotor drive system.

(b) *Arrangement.* Rotor drive systems must be arranged as follows:

(1) Each rotor drive system of multi-engine rotorcraft must be arranged so that each rotor necessary for operation and control will continue to be driven by the remaining engines if any engine fails.

(2) For single-engine rotorcraft, each rotor drive system must be so arranged that each rotor necessary for control in autorotation will continue to be driven by the main rotors after disengagement of the engine from the main and auxiliary rotors.

(3) Each rotor drive system must incorporate a unit for each engine to automatically disengage that engine from the main and auxiliary rotors if that engine fails.

(4) If a torque limiting device is used in the rotor drive system, it must be located so as to allow continued control of the rotorcraft when the device is operating.

(5) If the rotors must be phased for intermeshing, each system must provide constant and positive phase relationship under any operating condition.

(6) If a rotor dephasing device is incorporated, there must be means to keep the rotors locked in proper phase before operation.

[(Amdt. 29–12, Eff. 2/1/77)]

§ 29.921 Rotor brake.

If there is a means to control the rotation of the rotor drive system independently of the engine, any limitations on the use of that means must be section, for at least 200 hours plus the time required to meet the requirements of paragraphs (b)(2), (b)(3), and (k) of this section. These tests must be conducted as follows:]

(1) Ten-hour test cycles must be used, except that the test cycle must be extended to include the OEI test of paragraphs (b)(2) and (k) of this section, if OEI ratings are requested.

(2) The tests must be conducted on the rotorcraft.

(3) The test torque and rotational speed must be—

(i) Determined by the powerplant limitations; and

(ii) Absorbed by the rotors to be approved for the rotorcraft.

(b) *Endurance tests, takeoff run.* The takeoff run must be conducted as follows:

(1) [Except as prescribed in paragraphs (b)(2) and (b)(3) of this section, the takeoff torque run must consist of 1 hour of alternate runs of 5 minutes at takeoff torque and the maximum speed for use with takeoff torque, and 5 minutes at as low an engine idle speed as practicable. The engine must be declutched from the rotor drive system, and the rotor brake, if furnished and so intended, must be applied during the first minute of the idle run. During the remaining 4 minutes of the idle run, the clutch must be engaged so that the engine drives the rotors at the minimum practical r.p.m. The engine and the rotor drive system must be accelerated at the maximum rate. When declutching the engine, it must be decelerated rapidly enough to allow the operation of the overrunning clutch.]

(2) For helicopters for which the use of a 2½-minute OEI rating is requested, the takeoff run must be conducted as prescribed in paragraph (b)(1) of this section, except for the third and sixth runs for which the takeoff torque and the maximum speed for use with takeoff torque are prescribed in that paragraph. For these runs, the following apply:

(i) Each run must consist of at least one period of 2½ minutes with takeoff torque and

[(3) For multiengine, turbine-powered rotorcraft for which the use of 30-second/2-minute OEI power is requested, the takeoff run must be conducted as prescribed in paragraph (b)(1) of this section except for the following:

[(i) Immediately following any one 5-minute power-on run required by paragraph (b)(1) of this section, each power source must simulate a failure, in turn, and apply the maximum torque and the maximum speed for use with 30-second OEI power to the remaining affected drive system power inputs for not less than 30 seconds, followed by application of the maximum torque and the maximum speed for use with 2-minute OEI power for not less than 2 minutes. At least one run sequence must be conducted from a simulated "flight idle" condition. When conducted on a bench test, the test sequence must be conducted following stabilization at takeoff power.

[(ii) For the purpose of this paragraph, an affected power input includes all parts of the rotor drive system which can be adversely affected by the application of higher or asymmetric torque and speed prescribed by the test.

[(iii) This test may be conducted on a representative bench test facility when engine limitations either preclude repeated use of this power or would result in premature engine removals during the test. The loads, the vibration frequency, and the methods of application to the affected rotor drive system components must be representative of rotorcraft conditions. Test components must be those used to show compliance with the remainder of this section.]

(c) *Endurance tests, maximum continuous run.* Three hours of continuous operation at maximum continuous torque and the maximum speed for use with maximum continuous torque must be conducted as follows:

(1) The main rotor controls must be operated at a minimum of 15 times each hour through the main rotor pitch positions of maximum vertical thrust, maximum forward thrust component, maximum aft thrust component, maximum left thrust component, and maximum right thrust

ing torque.

(3) Each maximum control position must be held for at least 10 seconds, and the rate of change of control position must be at least as rapid as that for normal operation.

(d) *Endurance tests; 90 percent of maximum continuous run.* One hour of continuous operation at 90 percent of maximum continuous torque and the maximum speed for use with 90 percent of maximum continuous torque must be conducted.

(e) *Endurance tests; 80 percent of maximum continuous run.* One hour of continuous operation at 80 percent of maximum continuous torque and the minimum speed for use with 80 percent of maximum continuous torque must be conducted.

(f) *Endurance tests; 60 percent of maximum continuous run.* Two hours or, for helicopters for which the use of either 30-minute OEI power or continuous OEI power is requested, 1 hour of continuous operation at 60 percent of maximum continuous torque and the minimum speed for use with 60 percent of maximum continuous torque must be conducted.

(g) *Endurance tests; engine malfunctioning run.* It must be determined whether malfunctioning of components, such as the engine fuel or ignition systems, or whether unequal engine power can cause dynamic conditions detrimental to the drive system. If so, a suitable number of hours of operation must be accomplished under those conditions, 1 hour of which must be included in each cycle, and the remaining hours of which must be accomplished at the end of the 20 cycles. If no detrimental condition results, an additional hour of operation in compliance with paragraph (b) of this section must be conducted in accordance with the run schedule of paragraph (b)(1) of this section without consideration of paragraph (b)(2) of this section.

(h) *Endurance tests; overspeed run.* One hour of continuous operation must be conducted at maximum continuous torque and the maximum power-on overspeed expected in service, assuming that speed and torque limiting devices, if any, function properly.

(i) *Endurance tests; rotor control positions.* When the rotor controls are not being cycled during

cent.

(3) For the right thrust component, 10 percent.

(4) For the left thrust component, 10 percent.

(5) For the aft thrust component, 10 percent.

(j) *Endurance tests, clutch and brake engagements.* A total of at least 400 clutch and brake engagements, including the engagements of paragraph (b) of this section, must be made during the takeoff torque runs and, if necessary, at each change of torque and speed throughout the test. In each clutch engagement, the shaft on the driven side of the clutch must be accelerated from rest. The clutch engagements must be accomplished at the speed and by the method prescribed by the applicant. During deceleration after each clutch engagement, the engines must be stopped rapidly enough to allow the engines to be automatically disengaged from the rotors and rotor drives. If a rotor brake is installed for stopping the rotor, the clutch, during brake engagements, must be disengaged above 40 percent of maximum continuous rotor speed and the rotors allowed to decelerate to 40 percent of maximum continuous rotor speed, at which time the rotor brake must be applied. If the clutch design does not allow stopping the rotors with the engine running, or if no clutch is provided, the engine must be stopped before each application of the rotor brake, and then immediately be started after the rotors stop.

(k) *Endurance tests, OEI power run.*

(1) *30-minute OEI power run.* For rotorcraft for which the use of 30-minute OEI power is requested, a run at 30-minute OEI torque and the maximum speed for use with 30-minute OEI torque must be conducted as follows: For each engine, in sequence, that engine must be inoperative and the remaining engines must be run for a 30-minute period.

(2) *Continuous OEI power run.* For rotorcraft for which the use of continuous OEI power is requested, a run at continuous OEI torque and the maximum speed for use with continuous OEI torque must be conducted as follows: For each engine, in sequence, that engine must be inoperative and the remaining engines must be run for 1 hour.

tests or by other acceptable methods. In addition, a level of safety equal to that of the main rotors must be provided for—

(1) Each component in the rotor drive system whose failure would cause an uncontrolled landing;

(2) Each component essential to the phasing of rotors on multirotor rotorcraft, or that furnishes a driving link for the essential control of rotors in autorotation; and

(3) Each component common to two or more engines on multiengine rotorcraft.

(n) *Special tests.* Each rotor drive system designed to operate at two or more gear ratios must be subjected to special testing for durations necessary to substantiate the safety of the rotor drive system.

(o) Each part tested as prescribed in this section must be in a serviceable condition at the end of the tests. No intervening disassembly which might affect test results may be conducted.

(p) *Endurance tests; operating lubricants.* To be approved for use in rotor drive and control systems, lubricants must meet the specifications of lubricants used during the tests prescribed by this section. Additional or alternate lubricants may be qualified by equivalent testing or by comparative analysis of lubricant specifications and rotor drive and control system characteristics. In addition—

(1) At least three 10-hour cycles required by this section must be conducted with transmission and gearbox lubricant temperatures, at the location prescribed for measurement, not lower than the maximum operating temperature for which approval is requested;

(2) For pressure lubricated systems, at least three 10-hour cycles required by this section must be conducted with the lubricant pressure, at the location prescribed for measurement, not higher than the minimum operating pressure for which approval is requested; and

(3) The test conditions of paragraphs (p)(1) and (p)(2) of this section must be applied simultaneously and must be extended to include

ational tests, and vibratory investigations necessary to determine that the rotor drive mechanism is safe, must be performed.

(b) If turbine engine torque output to the transmission can exceed the highest engine or transmission torque limit, and that output is not directly controlled by the pilot under normal operating conditions (such as where the primary engine power control is accomplished through the flight control), the following test must be made:

(1) Under conditions associated with all engines operating, make 200 applications, for 10 seconds each, of torque that is at least equal to the lesser of—

(i) The maximum torque used in meeting § 29.923 plus 10 percent; or

(ii) The maximum torque attainable under probable operating conditions, assuming that torque limiting devices, if any, function properly.

(2) For multiengine rotorcraft under conditions associated with each engine, in turn, becoming inoperative, apply to the remaining transmission torque inputs the maximum torque attainable under probable operating conditions, assuming that torque limiting devices, if any, function properly. Each transmission input must be tested at this maximum torque for at least fifteen minutes.

(c) *Lubrication system failure.* For lubrication systems required for proper operation of rotor drive systems, the following apply:

(1) *Category A.* Unless such failures are extremely remote, it must be shown by test that any failure which results in loss of lubricant in any normal use lubrication system will not prevent continued safe operation, although not necessarily without damage, at a torque and rotational speed prescribed by the applicant for continued flight, for at least 30 minutes after perception by the flightcrew of the lubrication system failure or loss of lubricant.

(2) *Category B.* The requirements of Category A apply except that the rotor drive system need only be capable of operating under autorotative conditions for a least 15 minutes.

speed limits need not be exceeded. These runs must be conducted as follows:

(1) Overspeed runs must be alternated with stabilizing runs of from 1 to 5 minutes duration each at 60 to 80 percent of maximun continuous speed.

(2) Acceleration and deceleration must be accomplished in a period not longer than 10 seconds (except where maximum engine acceleration rate will require more than 10 seconds), and the time for changing speeds may not be deducted from the specified time for the overspeed runs.

(3) Overspeed runs must be made with the rotors in the flattest pitch for smooth operation.

(e) The tests prescribed in paragraphs (b) and (d) of this section must be conducted on the rotorcraft and the torque must be absorbed by the rotors to be installed, except that other ground or flight test facilities with other appropriate methods of torque absorption may be used if the conditions of support and vibration closely simulate the conditions that would exist during a test on the rotorcraft.

(f) Each test prescribed by this section must be conducted without intervening disassembly and, except for the lubrication system failure test required by paragraph (c) of this section, each part tested must be in a serviceable condition at the conclusion of the test.

[(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–13, Eff. 5/2/77); (Amdt. 29–17, Eff. 12/1/78; (Amdt. 29–26, Eff. 10/3/88)]

§ 29.931 Shafting critical speed.

(a) The critical speeds of any shafting must be determined by demonstration except that analytical methods may be used if reliable methods of analysis are available for the particular design.

(b) If any critical speed lies within, or close to, the operating ranges for idling, power-on, and autorotative conditions, the stresses occurring at that speed must be within safe limits. This must be shown by tests.

(c) If analytical methods are used and show that no critical speed lies within the permissible operat- must have provision for lubrication.

§ 29.939 Turbine engine operating characteristics.

(a) Turbine engine operating characteristics must be investigated in flight to determine that no adverse characteristics (such as stall, surge, or flameout) are present, to a hazardous degree, during normal and emergency operation within the range of operating limitations of the rotorcraft and of the engine.

(b) The turbine engine air inlet system may not, as a result of airflow distortion during normal operation, cause vibration harmful to the engine.

(c) For governor-controlled engines, it must be shown that there exists no hazardous torsional instability of the drive system associated with critical combinations of power, rotational speed, and control displacement.

[(Amdt. 29–2, Eff. 6/4/67); (Amdt. 29–12, Eff. 2/1/77)]

FUEL SYSTEM

§ 29.951 General.

(a) Each fuel system must be constructed and arranged to ensure a flow of fuel at a rate and pressure established for proper engine and auxiliary power unit functioning under any likely operating conditions, including the maneuvers for which certification is requested and during which the engine or auxiliary power unit is permitted to be in operation.

(b) Each fuel system must be arranged so that—

(1) No engine or fuel pump can draw fuel from more than one tank at a time; or

(2) There are means to prevent introducing air into the system.

(c) Each fuel system for a turbine engine must be capable of sustained operation throughout its flow and pressure range with fuel initially saturated with water at 80° F. and having 0.75 cc. of free water per gallon added and cooled to the most impact (crash landing), the fuel systems must incorporate the design features of this section. These systems must be shown to be capable of sustaining the static and dynamic deceleration loads of this section, considered as ultimate loads acting alone, measured at the system component's center of gravity without structural damage to system components, fuel tanks, or their attachments that would leak fuel to an ignition source.

(a) *Drop test requirements.* Each tank, or the most critical tank, must be drop-tested as follows:

(1) The drop height must be at least 50 feet.

(2) The drop impact surface must be nondeforming.

(3) The tank must be filled with water to 80 percent of the normal, full capacity.

(4) The tank must be enclosed in a surrounding structure representative of the installation unless it can be established that the surrounding structure is free of projections or other design features likely to contribute to rupture of the tank.

(5) The tank must drop freely and impact in a horizontal position ±10°.

(6) After the drop test, there must be no leakage.

(b) *Fuel tank load factors.* Except for fuel tanks located so that tank rupture with fuel release to either significant ignition sources, such as engines, heaters, and auxiliary power units, or occupants is extremely remote, each fuel tank must be designed and installed to retain its contents under the following ultimate inertial load factors, acting alone.

(1) For fuel tanks in the cabin:

(i) Upward—4g.

(ii) Forward—16g.

(iii) Sideward—8g.

(iv) Downward—20g.

(2) For fuel tanks located above or behind the crew or passenger compartment that, if loosened, could injure an occupant in an emergency landing:

(i) Upward—1.5g.

(ii) Forward—8g.

(iii) Sideward—2g.

components to each other or to local rotorcraft structure is demonstrated to be extremely improbable or unless other means are provided. The couplings or equivalent devices must be installed at all fuel tank-to-fuel line connections, tank-to-tank interconnects, and at other points in the fuel system where local structural deformation could lead to the release of fuel.

(1) The design and construction of self-sealing breakaway couplings must incorporate the following design features:

(i) The load necessary to separate a breakaway coupling must be between 25 to 50 percent of the minimum ultimate failure load (ultimate strength) of the weakest component in the fluid-carrying line. The separation load must in no case be less than 300 pounds, regardless of the size of the fluid line.

(ii) A breakaway coupling must separate whenever its ultimate load (as defined in paragraph (c)(1)(i) of this section) is applied in the failure modes most likely to occur.

(iii) All breakaway couplings must incorporate design provisions to visually ascertain that the coupling is locked together (leak-free) and is open during normal installation and service.

(iv) All breakaway couplings must incorporate design provisions to prevent uncoupling or unintended closing due to operational shocks, vibrations, or accelerations.

(v) No breakaway coupling design may allow the release of fuel once the coupling has performed its intended function.

(2) All individual breakaway couplings, coupling fuel feed systems, or equivalent means must be designed, tested, installed, and maintained so that inadvertent fuel shutoff in flight is improbable in accordance with § 29.955(a) and must comply with the fatigue evaluation requirements of § 29.571 without leaking.

(3) Alternate, equivalent means to the use of breakaway couplings must not create a survivable impact-induced load on the fuel line to which it is installed greater than 25 to 50 percent of

or locally deformable attachments of fuel tanks and fuel system components to local rotorcraft structure must be used. The attachment of fuel tanks and fuel system components to local rotorcraft structure, whether frangible or locally deformable, must be designed such that its separation or relative local deformation will occur without rupture or local tear-out of the fuel tank or fuel system components that will cause fuel leakage. The ultimate strength of frangible or deformable attachments must be as follows:

(1) The load required to separate a frangible attachment from its support structure, or deform a locally deformable attachment relative to its support structure, must be between 25 and 50 percent of the minimum ultimate load (ultimate strength) of the weakest component in the attached system. In no case may the load be less than 300 pounds.

(2) A frangible or locally deformable attachment must separate or locally deform as intended whenever its ultimate load (as defined in paragraph (d)(1) of this section) is applied in the modes most likely to occur.

(3) All frangible or locally deformable attachments must comply with the fatigue requirements of § 29.571.

(e) *Separation of fuel and ignition sources.* To provide maximum crash resistance, fuel must be located as far as practicable from all occupiable areas and from all potential ignition sources.

(f) *Other basic mechanical design criteria.* Fuel tanks, fuel lines, electrical wires, and electrical devices must be designed, constructed, and installed, as far as practicable, to be crash resistant.

(g) *Rigid or semirigid fuel tanks.* Rigid or semirigid fuel tank or bladder walls must be impact and tear resistant.]

[(Amdt. 29–35, Eff. 11/2/94)]

§ 29.953 Fuel system independence.

(a) For category A rotorcraft—

(1) The fuel system must meet the requirements of § 29.903(b); and

§ 29.954 Fuel system lightning protection.

The fuel system must be designed and arranged to prevent the ignition of fuel vapor within the system by—

(a) Direct lightning strikes to areas having a high probability of stroke attachment;

(b) Swept lightning strokes to areas where swept strokes are highly probable; and

(c) Corona and streamering at fuel vent outlets.

[(Amdt. 29–26, Eff. 10/3/88)]

§ 29.955 Fuel flow.

(a) *General.* The fuel system for each engine must provide the engine with at least 100 percent of the fuel required under all operating and maneuvering conditions to be approved for the rotorcraft, including, as applicable, the fuel required to operate the engines under the test conditions required by § 29.927. Unless equivalent methods are used, compliance must be shown by test during which the following provisions are met, except that combinations of conditions which are shown to be improbable need not be considered.

(1) The fuel pressure, corrected for accelerations (load factors), must be within the limits specified by the engine type certificate data sheet.

(2) The fuel level in the tank may not exceed that established as the unusable fuel supply for that tank under § 29.959, plus that necessary to conduct the test.

(3) The fuel head between the tank and the engine must be critical with respect to rotorcraft flight attitudes.

(4) The fuel flow transmitter, if installed, and the critical fuel pump (for pump-fed systems) must be installed to produce (by actual or simulated failure) the critical restriction to fuel flow to be expected from component failure.

(5) Critical values of engine rotational speed, electrical power, or other sources of fuel pump motive power must be applied.

the fuel system requires fuel to be transferred to another tank, the transfer must occur automatically via a system which has been shown to maintain the fuel level in the receiving tank within acceptable limits during flight or surface operation of the rotorcraft.

(c) *Multiple fuel tanks.* If an engine can be supplied with fuel from more than one tank, the fuel system, in addition to having appropriate manual switching capability, must be designed to prevent interruption of fuel flow to the engine, without attention by the flightcrew, when any tank supplying fuel to that engine is depleted of usable fuel during normal operation and any other tank that normally supplies fuel to that engine alone contains usable fuel.

[(Amdt. 29–2, Eff. 6/4/67); (Amdt. 29–26, Eff. 10/3/88)]

§ 29.957 Flow between interconnected tanks.

(a) Where tank outlets are interconnected and allow fuel to flow between them due to gravity or flight accelerations, it must be impossible for fuel to flow between tanks in quantities great enough to cause overflow from the tank vent in any sustained flight condition.

(b) If fuel can be pumped from one tank to another in flight—

(1) The design of the vents and the fuel transfer system must prevent structural damage to tanks from overfilling; and

(2) There must be means to warn the crew before overflow through the vents occurs.

§ 29.959 Unusable fuel supply.

The unusable fuel supply for each tank must be established as not less than the quantity at which the first evidence of malfunction occurs under the most adverse fuel feed condition occurring under any intended operations and flight maneuvers involving that tank.

tion is shown in weather cold enough to interfere with the proper conduct of the test, each fuel tank surface, fuel line, and other fuel system parts subject to cold air must be insulated to simulate, insofar as practicable, flight in hot weather.

[(Amdt. 29–26, Eff. 10/3/88)]

§ 29.963 Fuel tanks: General.

(a) Each fuel tank must be able to withstand, without failure, the vibration, inertia, fluid, and structural loads to which it may be subjected in operation.

[(b)] [Each flexible fuel tank bladder or liner must be approved or shown to be suitable for the particular application and must be puncture resistant. Puncture resistance must be shown by meeting the TSO–C80, paragraph 16.0, requirements using a minimum puncture force of 370 pounds.]

([c]) Each integral fuel tank liner must have facilities for inspection and repair of its interior.

([d]) The maximum exposed surface temperature of all components in the fuel tank must be less by a safe margin than the lowest expected autoignition temperature of the fuel or fuel vapor in the tank. Compliance with this requirement must be shown under all operating conditions and under all normal or malfunction conditions of all components inside the tank.

[(e) Each fuel tank installed in personnel compartments must be isolated by fume-proof and fuel-proof enclosures that are drained and vented to the exterior of the rotorcraft. The design and construction of the enclosures must provide necessary protection for the tank, must be crash resistant during a survivable impact in accordance with § 29.952, and must be adequate to withstand loads and abrasions to be expected in personnel compartments.]

(Amdt. 29–26, Eff. 10/3/88); [(Amdt. 29–35, Eff. 11/2/94)] be subjected to a pressure of 3.5 p.s.i. unless the pressure developed during maximum limit acceleration or emergency deceleration with a full tank exceeds this value, in which case a hydrostatic head, or equivalent test, must be applied to duplicate the acceleration loads as far as possible. However, the pressure need not exceed 3.5 p.s.i. on surfaces not exposed to the acceleration loading.

(c) Each nonmetallic tank with walls supported by the rotorcraft structure must be subjected to the following tests:

(1) A pressure test of at least 2.0 p.s.i. This test may be conducted on the tank alone in conjunction with the test specified in paragraph (c)(2) of this section.

(2) A pressure test, with the tank mounted in the rotorcraft structure, equal to the load developed by the reaction of the contents, with the tank full, during maximum limit acceleration or emergency deceleration. However, the pressure need not exceed 2.0 p.s.i. on surfaces not exposed to the acceleration loading.

(d) Each tank with large unsupported or unstiffened flat areas, or with other features whose failure or deformation could cause leakage, must be subjected to the following test or its equivalent:

(1) Each complete tank assembly and its supports must be vibration tested while mounted to simulate the actual installation.

(2) The tank assembly must be vibrated for 25 hours while two-thirds full of any suitable fluid. The amplitude of vibration may not be less than one thirty-second of an inch unless otherwise substantiated.

(3) The test frequency of vibration must be as follows:

(i) If no frequency of vibration resulting from any r.p.m. within the normal operating range of engine or rotor system speeds is critical, the test frequency of vibration, in number of cycles per minute, must, unless a frequency based on a more rational analysis is used, be the number obtained by averaging the maximum and minimum power-on engine speeds (r.p.m.) for reciprocating engine powered rotor-

operating range of engine or rotor system speeds is critical, the most critical of these frequencies must be the test frequency.

(4) Under paragraph (d)(3)(ii) and (iii), the time of test must be adjusted to accomplish the same number of vibration cycles as would be accomplished in 25 hours at the frequency specified in paragraph (d)(3)(i) of this section.

(5) During the test, the tank assembly must be rocked at the rate of 16 to 20 complete cycles per minute through an angle of 15° on both sides of the horizontal (30° total), about the most critical axis, for 25 hours). If motion about more than one axis is likely to be critical, the tank must be rocked about each critical axis for 12½ hours.

[(Amdt. 29–13, Eff. 5/2/77)]

§ 29.967 Fuel tank installation.

(a) Each fuel tank must be supported so that tank loads are not concentrated on unsupported tank surfaces. In addition—

(1) There must be pads, if necessary, to prevent chafing between each tank and its supports;

(2) The padding must be nonabsorbent or treated to prevent the absorption of fuel;

(3) If flexible tank liners are used, they must be supported so that they are not required to withstand fluid loads; and

(4) Each interior surface of tank compartments must be smooth and free of projections that could cause wear of the liner, unless—

(i) There are means for protection of the liner at those points; or

(ii) The construction of the liner itself provides such protection.

(b) Any spaces adjacent to tank surfaces must be adequately ventilated to avoid accumulation of fuel or fumes in those spaces due to minor leakage. If the tank is in a sealed compartment, ventilation may be limited to drain holes that prevent clogging and that prevent excessive pressure resulting from altitude changes. If flexible tank liners are installed, the venting arrangement for the spaces between the

(Amdt. 29–26, Eff. 10/3/88); [(Amdt. 29–35, Eff. 11/2/94)]

§ 29.969 Fuel tank expansion space.

Each fuel tank or each group of fuel tanks with interconnected vent systems must have an expansion space of not less than 2 percent of the combined tank capacity. It must be impossible to fill the fuel tank expansion space inadvertently with the rotorcraft in the normal ground attitude.

[(Amdt. 29–26, Eff. 10/3/88)]

§ 29.971 Fuel tank sump.

(a) Each fuel tank must have a sump with a capacity of not less than the greater of—

(1) 0.10 percent of the tank capacity of—

(2) One-sixteenth gallon.

(b) The capacity prescribed in paragraph (a) of this section must be effective with the rotorcraft in any normal attitude, and must be located so that the sump contents cannot escape through the tank outlet opening.

(c) Each fuel tank must allow drainage of hazardous quantities of water from each part of the tank to the sump with the rotorcraft in any ground attitude to be expected in service.

(d) Each fuel tank sump must have a drain that allows complete drainage of the sump on the ground.

[(Amdt. 29–12, Eff. 2/1/77); (Amdt. 29–26, Eff. 10/3/88)]

§ 29.973 Fuel tank filler connection.

(a) [Each fuel tank filler connection must prevent the entrance of fuel into any part of the rotorcraft other than the tank itself during normal operations and must be crash resistant during a survivable impact in accordance with § 29.952(c). In addition—

(1) Each filler must be marked as prescribed in § 29.1557(c)(1);

(2) Each recessed filler connection that can retain any appreciable quantity of fuel must have

§ 29.975 Fuel tank vents and carburetor vapor vents.

(a) *Fuel tank vents.* Each fuel tank must be vented from the top part of the expansion space so that venting is effective under normal flight conditions. In addition—

(1) The vents must be arranged to avoid stoppage by dirt or ice formation;

(2) The vent arrangement must prevent siphoning of fuel during normal operation;

(3) The venting capacity and vent pressure levels must maintain acceptable differences of pressure between the interior and exterior of the tank during—

(i) Normal flight operation;

(ii) Maximum rate of ascent and descent; and

(iii) Refueling and defueling (where applicable);

(4) Airspaces of tanks with interconnected outlets must be interconnected;

(5) There may be no point in any vent line where moisture can accumulate with the rotorcraft in the ground attitude or the level flight attitude, unless drainage is provided;

(6) No vent or drainage provision may end at any point—

(i) Where the discharge of fuel from the vent outlet would constitute a fire hazard; or

(ii) From which fumes could enter personnel compartments; and

(7) [The venting system must be designed to minimize spillage of fuel through the vents to an ignition source in the event of a rollover during landing, ground operations, or a survivable impact, unless a rollover is shown to be extremely remote.]

(b) *Carburetor vapor vents.* Each carburetor with vapor elimination connections must have a vent line to lead vapors back to one of the fuel tanks. In addition—

(1) Each vent system must have means to avoid stoppage by ice; and

(a) There must be a fuel strainer for the fuel tank outlet or for the booster pump. This strainer must—

(1) For reciprocating engine powered airplanes, have 8 to 16 meshes per inch; and

(2) For turbine engine powered airplanes, prevent the passage of any object that could restrict fuel flow or damage any fuel system component.

(b) The clear area of each fuel tank outlet strainer must be at least five times the area of the outlet line.

(c) The diameter of each strainer must be at least that of the fuel tank outlet.

(d) Each finger strainer must be accessible for inspection and cleaning.

[(Amdt. 29–12, Eff. 2/1/77)]

§ 29.979 Pressure refueling and fueling provisions below fuel level.

(a) Each fueling connection below the fuel level in each tank must have means to prevent the escape of hazardous quantities of fuel from that tank in case of malfunction of the fuel entry valve.

(b) For systems intended for pressure refueling, a means in addition to the normal means for limiting the tank content must be installed to prevent damage to the tank in case of failure of the normal means.

(c) The rotorcraft pressure fueling system (not fuel tanks and fuel tank vents) must withstand an ultimate load that is 2.0 times the load arising from the maximum pressure, including surge, that is likely to occur during fueling. The maximum surge pressure must be established with any combination of tank valves being either intentionally or inadvertently closed.

(d) The rotorcraft defueling system (not including fuel tanks and fuel tank vents) must withstand an ultimate load that is 2.0 times the load arising from the maximum permissible defueling pressure (positive or negative) at the rotorcraft fueling connection.

[(Amdt. 29–12, Eff. 2/1/77)]

(2) Any component required for pump operation except the engine served by that pump.

(b) The following fuel pump installation requirements apply:

(1) When necessary to maintain the proper fuel pressure—

(i) A connection must be provided to transmit the carburetor air intake static pressure to the proper fuel pump relief valve connection; and

(ii) The gauge balance lines must be independently connected to the carburetor inlet pressure to avoid incorrect fuel pressure readings.

(2) The installation of fuel pumps having seals or diaphragms that may leak must have means for draining leaking fuel.

(3) Each drain line must discharge where it will not create a fire hazard.

[(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–13, Eff. 5/2/77); (Amdt. 29–26, Eff. 10/3/88)]

§ 29.993 Fuel system lines and fittings.

(a) Each fuel line must be installed and supported to prevent excessive vibration and to withstand loads due to fuel pressure, valve actuation, and accelerated flight conditions.

(b) Each fuel line connected to components of the rotorcraft between which relative motion could exist must have provisions for flexibility.

(c) Each flexible connection in fuel lines that may be under pressure or subjected to axial loading must use flexible hose assemblies.

(d) Flexible hose must be approved.

(e) No flexible hose that might be adversely affected by high temperatures may be used where excessive temperatures will exist during operation or after engine shutdown.

§ 29.995 Fuel valves.

In addition to meeting the requirements of § 29.1189, each fuel valve must—

(a) [Reserved]

system component which is susceptible to fuel contamination, including but not limited to the fuel metering device or an engine positive displacement pump, whichever is nearer the fuel tank outlet. This fuel strainer or filter must—

(a) Be accessible for draining and cleaning and must incorporate a screen or element which is easily removable;

(b) Have a sediment trap and drain, except that it need not have a drain if the strainer or filter is easily removable for drain purposes;

(c) Be mounted so that its weight is not supported by the connecting lines or by the inlet or outlet connections of the strainer or filter itself, unless adequate strength margins under all loading conditions are provided in the lines and connections; and

(d) Provide a means to remove from the fuel any contaminant which would jeopardize the flow of fuel through rotorcraft or engine fuel system components required for proper rotorcraft or engine fuel system components required for proper rotorcraft or engine fuel system operation.

[(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–10, Eff. 10/31/74); (Amdt. 29–22, Eff. 3/26/84); (Amdt. 29–26, Eff. 10/3/88)]

§ 29.999 Fuel system drains.

(a) There must be at least one accessible drain at the lowest point in each fuel system to completely drain the system with the rotorcraft in any ground attitude to be expected in service.

(b) Each drain required by paragraph (a) of this section including the drains prescribed in § 29.971 must—

(1) Discharge clear of all parts of the rotorcraft;

(2) Have manual or automatic means to ensure positive closure in the off position; and

(3) Have a drain valve—

(i) That is readily accessible and which can be easily opened and closed; and

(a) Fuel jettisoning must be safe during all flight regimes for which jettisoning is to be authorized.

(b) In showing compliance with paragraph (a) of this section, it must be shown that—

(1) The fuel jettisoning system and its operation are free from fire hazard;

(2) No hazard results from fuel or fuel vapors which impinge on any part of the rotorcraft during fuel jettisoning; and

(3) Controllability of the rotorcraft remains satisfactory throughout the fuel jettisoning operation.

(c) Means must be provided to automatically prevent jettisoning fuel below the level required for an all-engine climb at maximum continuous power from sea level to 5,000 feet altitude and cruise thereafter for 30 minutes at maximum range engine power.

(d) The controls for any fuel jettisoning system must be designed to allow flight personnel (minimum crew) to safely interrupt fuel jettisoning during any part of the jettisoning operation.

(e) The fuel jettisoning system must be designed to comply with the powerplant installation requirements of § 29.901(c).

(f) An auxiliary fuel jettisoning system which meets the requirements of paragraphs (a), (b), (d), and (e) of this section may be installed to jettison additional fuel provided it has separate and independent controls.

[(Amdt. 29–26, Eff. 10/3/88)]

OIL SYSTEM

§ 29.1011 Engines: General.

(a) Each engine must have an independent oil system that can supply it with an appropriate quantity of oil at a temperature not above that safe for continuous operation.

(b) The usable oil capacity of each system may not be less than the product of the endurance of the rotorcraft under critical operating conditions and the maximum allowable oil consumption of the tion of the engine.

(d) The ability of the engine oil cooling provisions to maintain the oil temperature at or below the maximum established value must be shown under the applicable requirements of §§ 29.1041 through 29.1049.

[(Amdt. 29–26, Eff. 10/3/88)]

§ 29.1013 Oil tanks.

(a) *Installation.* Each oil tank installation must meet the requirements of § 29.967.

(b) *Expansion space.* Oil tank expansion space must be provided so that—

(1) Each oil tank used with a reciprocating engine has an expansion space of not less than the greater of 10 percent of the tank capacity of 0.5 gallon, and each oil tank used with a turbine engine has an expansion space of not less than 10 percent of the tank capacity;

(2) Each reserve oil tank not directly connected to any engine has an expansion space of not less than 2 percent of the tank capacity; and

(3) It is impossible to fill the expansion space inadvertently with the rotorcraft in the normal ground attitude.

(c) *Filler connection.* Each recessed oil tank filler connection that can retain any appreciable quantity of oil must have a drain that discharges clear of the entire rotorcraft. In addition—

(1) Each oil tank filler cap must provide an oil-tight seal under the pressure expected in operation;

(2) For category A rotorcraft, each oil tank filler cap or filler cap cover must incorporate features that provide a warning when caps are not fully locked or seated on the filler connection; and

(3) Each oil filler must be marked under § 29.1557(c)(2).

(d) *Vent.* Oil tanks must be vented as follows:

(1) Each oil tank must be vented from the top part of the expansion space so that venting is effective under all normal flight conditions.

outlet of each oil tank used with a turbine engine unless the external portion of the oil system (including oil tank supports) is fireproof.

(f) *Flexible liners.* Each flexible oil tank liner must be approved or shown to be suitable for the particular installation.

[(Amdt. 29–10, Eff. 10/31/74)]

§ 29.1015 Oil tank tests.

Each oil tank must be designed and installed so that—

(a) It can withstand, without failure, any vibration, inertia, and fluid loads to which it may be subjected in operation; and

(b) It meets the requirements of § 29.965, except that instead of the pressure specified in § 29.965(b)—

(1) For pressurized tanks used with a turbine engine, the test pressure may not be less than 5 p.s.i. plus the maximum operating pressure of the tank; and

(2) For all other tanks, the test pressure may not be less than 5 p.s.i.

[(Amdt. 29–10, Eff. 10/31/74)]

§ 29.1017 Oil lines and fittings.

(a) Each oil line must meet the requirements of § 29.993.

(b) Breather lines must be arranged so that—

(1) Condensed water vapor that might freeze and obstruct the line cannot accumulate at any point;

(2) The breather discharge will not constitute a fire hazard if foaming occurs, or cause emitted oil to strike the pilot's windshield; and

(3) The breather does not discharge into the engine air induction system.

§ 29.1019 Oil strainer or filter.

(a) Each turbine engine installation must incorporate an oil strainer or filter through which all established for the engine) to ensure that engine oil system functioning is not impaired when the oil is contaminated to a degree (with respect to particle size and density) that is greater than that established for the engine under part 33 of this chapter.

(3) The oil strainer or filter, unless it is installed at an oil tank outlet, must incorporate a means to indicate contamination before it reaches the capacity established in accordance with paragraph (a)(2) of this section.

(4) The bypass of a strainer or filter must be constructed and installed so that the release of collected contaminants is minimized by appropriate location of the bypass to ensure that collected contaminants are not in the bypass flow path.

(5) An oil strainer or filter that has no bypass, except one that is installed at an oil tank outlet, must have a means to connect it to the warning system required in § 29.1305(a)(18).

(b) Each oil strainer or filter in a powerplant installation using reciprocating engines must be constructed and installed so that oil will flow at the normal rate through the rest of the system with the strainer or filter element completely blocked.

[(Amdt. 29–10, Eff. 10/31/74); (Amdt. 29–22, Eff. 3/26/84); (Amdt. 29–26, Eff. 10/3/88)]

§ 29.1021 Oil system drains.

A drain (or drains) must be provided to allow safe drainage of the oil system. Each drain must—

(a) Be accessible; and

(b) Have manual or automatic means for positive locking in the closed position.

[(Amdt. 29–22, Eff. 3/26/84)]

§ 29.1023 Oil radiators.

(a) Each oil radiator must be able to withstand any vibration, inertia, and oil pressure loads to which it would be subjected in operation.

(b) Each oil radiator air duct must be located, or equipped, so that, in case of fire, and with the

(c) Each oil valve must have positive stops or suitable index provisions in the "on" and "off" positions and must be supported so that no loads resulting from its operation or from accelerated flight conditions are transmitted to the lines attached to the valve.

§ 29.1027 Transmission and gearboxes: General.

(a) The oil system for components of the rotor drive system that require continuous lubrication must be sufficiently independent of the lubrication systems of the engine(s) to ensure—

(1) Operation with any engine inoperative; and

(2) Safe autorotation.

(b) Pressure lubrication systems for transmissions and gearboxes must comply with the requirements of §§ 29.1013, paragraphs (c), (d), and (f) only, 29.1015, 29.1017, 29.1021, 29.1023, and 29.1337(d). In addition, the system must have—

(1) An oil strainer or filter through which all the lubricant flows, and must—

(i) Be designed to remove from the lubricant any contaminant which may damage transmission and drive system components or impede the flow of lubricant to a hazardous degree; and

(ii) Be equipped with a bypass constructed and installed so that—

(A) The lubricant will flow at the normal rate through the rest of the system with the strainer or filter completely blocked; and

(B) The release of collected contaminants is minimized by appropriate location of the bypass to ensure that collected contaminants are not in the bypass flowpath;

(iii) Be equipped with a means to indicate collection of contaminants on the filter or strainer at or before opening of the bypass;

(2) For each lubricant tank or sump outlet supplying lubrication to rotor drive systems and rotor drive system components, a screen to prevent entrance into the lubrication system of any object that might obstruct the flow of lubricant from the outlet to the filter required by paragraph

§ 29.1041 General.

(a) The powerplant and auxiliary power unit cooling provisions must be able to maintain the temperatures of power plant components, engine fluids, and auxiliary power unit components and fluids within the temperature limits established for these components and fluids, under ground, water, and flight operating conditions for which certification is requested, and after normal engine or auxiliary power shutdown, or both.

(b) There must be cooling provisions to maintain the fluid temperatures in any power transmission within safe values under any critical surface (ground or water) and flight operating conditions.

(c) Except for ground-use-only auxiliary power units, compliance with paragraphs (a) and (b) of this section must be shown by flight tests in which the temperatures of selected powerplant component and auxiliary power unit component, engine, and transmission fluids are obtained under the conditions prescribed in those paragraphs.

[(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–12, Eff. 2/1/77); (Amdt. 29–26, Eff. 10/3/88)]

§ 29.1043 Cooling tests.

(a) *General.* For the tests prescribed in § 29.1041(c), the following apply:

(1) If the tests are conducted under conditions deviating from the maximum ambient atmospheric temperature specified in paragraph (b) of this section, the recorded powerplant temperatures must be corrected under paragraphs (c) and (d) of this section, unless a more rational correction method is applicable.

(2) No corrected temperature determined under paragraph (a)(1) of this section may exceed established limits.

(3) The fuel used during the cooling tests must be of the minimum grade approved for the engines, and the mixture settings must be those used in normal operation.

(4) The test procedures must be as prescribed in §§ 29.1045 through 29.1049.

ture of −69.7 degrees F. is reached, above which altitude the temperature is considered constant at −69.7 degrees F. However, for winterization installations, the applicant may select a maximum ambient atmospheric temperature corresponding to sea level conditions of less than 100 degrees F.

(c) *Correction factor (except cylinder barrels).* Unless a more rational correction applies, temperatures of engine fluids and powerplant components (except cylinder barrels) for which temperature limits are established, must be corrected by adding to them the difference between the maximum ambient atmospheric temperature and the temperature of the ambient air at the time of the first occurrence of the maximum component or fluid temperature recorded during the cooling test.

(d) *Correction factor for cylinder barrel temperatures.* Cylinder barrel temperatures must be corrected by adding to them 0.7 times the difference between the maximum ambient atmospheric temperature and the temperature of the ambient air at the time of the first occurrence of the maximum cylinder barrel temperature recorded during the cooling test.

[(Amdt. 29–12, Eff. 2/1/77); (Amdt. 29–15, Eff. 3/1/78); (Amdt. 29–26, Eff. 10/3/88)]

§ 29.1045 Climb cooling test procedures.

(a) Climb cooling tests must be conducted under this section for—

(1) Category A rotorcraft; and

(2) Multiengine category B rotorcraft for which certification is requested under the category A powerplant installation requirements, and under the requirements of § 29.861(a) at the steady rate of climb or descent established under § 29.67(b).

(b) The climb or descent cooling tests must be conducted with the engine inoperative that produces the most adverse cooling conditions for the remaining engines and powerplant components.

(c) Each operating engine must—

(1) For helicopters for which the use of 30-minute OEI power is requested, be at 30-minute OEI power for 30 minutes, and then at maximum

(d) After temperatures have stabilized in flight, the climb must be—

(1) Begun from an altitude not greater than the lower of—

(i) 1,000 feet below the engine critical altitude; and

(ii) 1,000 feet below the maximum altitude at which the rate of climb is 150 f.p.m.; and

(2) Continued for at least 5 minutes after the occurrence of the highest temperature recorded, or until the rotorcraft reaches the maximum altitude for which certification is requested.

(e) For category B rotorcraft without a positive rate of climb, the descent must begin at the all-engine-critical altitude and end at the higher of—

(1) The maximum altitude at which level flight can be maintained with one engine operative; and

(2) Sea level.

(f) The climb or descent must be conducted at an airspeed representing a normal operational practice for the configuration being tested. However, if the cooling provisions are sensitive to rotorcraft speed, the most critical airspeed must be used, but need not exceed the speeds established under § 29.67(a)(2) or § 29.67(b). The climb cooling test may be conducted in conjunction with the takeoff cooling test of § 29.1047.

[(Amdt. 29–1, Eff. 8/12/65); (Amdt. 29–26, Eff. 10/3/88)]

§ 29.1047 Takeoff cooling test procedures.

(a) *Category A.* For each category A rotorcraft, cooling must be shown during takeoff and subsequent climb as follows:

(1) Each temperature must be stabilized while hovering in ground effect with—

(i) The power necessary for hovering;

(ii) The appropriate cowl flap and shutter settings; and

(iii) The maximum weight.

(4) At the end of the time interval prescribed in paragraph (b)(3) of this section, the power must be changed to that used in meeting § 29.67(a)(2) and the climb must be continued for—

(i) Thirty minutes, if 30-minute OEI power is used; or

(ii) At least 5 minutes after the occurrence of the highest temperature recorded, if continuous OEI power or maximum continuous power is used.

(5) The speeds must be those used in determining the takeoff flight path under § 29.59.

(b) *Category B.* For each category B rotorcraft, cooling must be shown during takeoff and subsequent climb as follows:

(1) Each temperature must be stabilized while hovering in ground effect with—

(i) The power necessary for hovering;

(ii) The appropriate cowl flap and shutter settings; and

(iii) The maximum weight.

(2) After the temperatures have stabilized, a climb must be started at the lowest practicable altitude with takeoff power.

(3) Takeoff power must be used for the same time interval as takeoff power is used in determining the takeoff flight path under § 29.63.

(4) At the end of the time interval prescribed in paragraph (a)(3) of this section, the power must be reduced to maximum continuous power and the climb must be continued for at least five minutes after the occurrence of the highest temperature recorded.

(5) The cooling test must be conducted at an airspeed corresponding to normal operating practice for the configuration being tested. However, if the cooling provisions are sensitive to rotorcraft speed, the most critical airspeed must be used, but need not exceed the speed for best rate of climb with maximum continuous power.

[(Amdt. 29–1, Eff. 8/12/65); (Amdt. 29–26, Eff. 10/3/88)] after the occurrence of the highest temperature recorded; and

(b) With maximum continuous power, maximum weight, and at the altitude resulting in zero rate of climb for this configuration, until at least five minutes after the occurrence of the highest temperature recorded.

INDUCTION SYSTEM

§ 29.1091 Air induction.

(a) The air induction system for each engine and auxiliary power unit must supply the air required by that engine and auxiliary power unit under the operating conditions for which certification is requested.

(b) Each engine and auxiliary power unit air induction system must provide air for proper fuel metering and mixture distribution with the induction system valves in any position.

(c) No air intake may open within the engine accessory section or within other areas of any powerplant compartment where emergence of backfire flame would constitute a fire hazard.

(d) Each reciprocating engine must have an alternate air source.

(e) Each alternate air intake must be located to prevent the entrance of rain, ice, or other foreign matter.

(f) For turbine engine powered rotorcraft and rotorcraft incorporating auxiliary power units—

(1) There must be means to prevent hazardous quantities of fuel leakage or overflow from drains, vents, or other components of flammable fluid systems from entering the engine or auxiliary power unit intake system; and

(2) The air inlet ducts must be located or protected so as to minimize the ingestion of foreign matter during takeoff, landing, and taxiing.

[(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–17, Eff. 12/1/78)]

(1) Each rotorcraft with sea level engines using conventional venturi carburetors has a preheater that can provide a heat rise of 90° F.;

(2) Each rotorcraft with sea level engines using carburetors tending to prevent icing has a preheater that can provide a heat rise of 70° F.;

(3) Each rotorcraft with altitude engines using conventional venturi carburetors has a preheater that can provide a heat rise of 120° F.; and

(4) Each rotorcraft with altitude engines using carburetors tending to prevent icing has a preheater that can provide a heat rise of 100° F.

(b) *Turbine engines.* (1) It must be shown that each turbine engine and its air inlet system can operate throughout the flight power range of the engine (including idling)—

(i) Without accumulating ice on engine or inlet system components that would adversely affect engine operation or cause a serious loss of power under the icing conditions specified in appendix C of this part; and

(ii) In snow, both falling and blowing, without adverse effect on engine operation, within the limitations established for the rotorcraft.

(2) Each turbine engine must idle for 30 minutes on the ground, with the air bleed available for engine icing protection at its critical condition, without adverse effect, in an atmosphere that is at a temperature between 15° and 30° F (between −9° and −1° C) and has a liquid water content not less than 0.3 grams per cubic meter in the form of drops having a mean effective diameter not less than 20 microns, followed by momentary operation at takeoff power or thrust. During the 30 minutes of idle operation, the engine may be run up periodically to a moderate power or thrust setting in a manner acceptable to the Administrator.

(c) *Supercharged reciprocating engines.* For each engine having a supercharger to pressurize the air before it enters the carburetor, the heat rise in the air caused by that supercharging at any altitude may be utilized in determining compliance with paragraph (a) of this section if the heat rise utilized is that which will be available, automatically, for and constructed to—

(a) Ensure ventilation of the preheater when the engine is operated in cold air;

(b) Allow inspection of the exhaust manifold parts that it surrounds; and

(c) Allow inspection of critical parts of the preheater itself.

§ 29.1103 Induction systems ducts and air duct systems.

(a) Each induction system duct upstream of the first stage of the engine supercharger and of the auxiliary power unit compressor must have a drain to prevent the hazardous accumulation of fuel and moisture in the ground attitude. No drain may discharge where it might cause a fire hazard.

(b) Each duct must be strong enough to prevent induction system failure from normal backfire conditions.

(c) Each duct connected to components between which relative motion could exist must have means for flexibility.

(d) Each duct within any fire zone for which a fire-extinguishing system is required must be at least—

(1) Fireproof, if it passes through any firewall; or

(2) Fire resistant, for other ducts, except that ducts for auxiliary power units must be fireproof within the auxiliary power unit fire zone.

(e) Each auxiliary power unit induction system duct must be fireproof for a sufficient distance upstream of the auxiliary power unit compartment to prevent hot gas reverse flow from burning through auxiliary power unit ducts and entering any other compartment or area of the rotorcraft in which a hazard would be created resulting from the entry of hot gases. The materials used to form the remainder of the induction system duct and plenum chamber of the auxiliary power unit must be capable of resisting the maximum heat conditions likely to occur.

(f) Each auxiliary power unit induction system duct must be constructed of materials that will not

(b) No screen may be in any part of the induction system that is the only passage through which air can reach the engine, unless it can be deiced by heated air;

(c) No screen may be deiced by alcohol alone; and

(d) It must be impossible for fuel to strike any screen.

§ 29.1107 Inter-coolers and after-coolers.

Each inter-cooler and after-cooler must be able to withstand the vibration, inertia, and air pressure loads to which it would be subjected in operation.

§ 29.1109 Carburetor air cooling.

It must be shown under § 29.1043 that each installation using two-stage superchargers has means to maintain the air temperature, at the carburetor inlet, at or below the maximum established value.

EXHAUST SYSTEM

§ 29.1121 General.

For powerplant and auxiliary power unit installations the following apply:

(a) Each exhaust system must ensure safe disposal of exhaust gases without fire hazard or carbon monoxide contamination in any personnel compartment.

(b) Each exhaust system part with a surface hot enough to ignite flammable fluids or vapors must be located or shielded so that leakage from any system carrying flammable fluids or vapors will not result in a fire caused by impingement of the fluids or vapors on any part of the exhaust system including shields for the exhaust system.

(c) Each component upon which hot exhaust gases could impinge, or that could be subjected to high temperatures from exhaust system parts, must be fireproof. Each exhaust system component must be separated by a fireproof shield from adjacent parts of the rotorcraft that are outside the engine and auxiliary power unit compartments.

(g) Each exhaust shroud must be ventilated or insulated to avoid, during normal operation, a temperature high enough to ignite any flammable fluids or vapors outside the shroud.

(h) If significant traps exist, each turbine engine exhaust system must have drains discharging clear of the rotorcraft, in any normal ground and flight attitudes, to prevent fuel accumulation after the failure of an attempted engine start.

[(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–13, Eff. 5/2/77)]

§ 29.1123 Exhaust piping.

(a) Exhaust piping must be heat and corrosion resistant, and must have provisions to prevent failure due to expansion by operating temperatures.

(b) Exhaust piping must be supported to withstand any vibration and inertia loads to which it would be subjected in operation.

(c) Exhaust piping connected to components between which relative motion could exist must have provisions for flexibility.

§ 29.1125 Exhaust heat exchangers.

For reciprocating engine powered rotorcraft the following apply:

(a) Each exhaust heat exchanger must be constructed and installed to withstand the vibration, inertia, and other loads to which it would be subjected in operation. In addition—

(1) Each exchanger must be suitable for continued operation at high temperatures and resistant to corrosion from exhaust gases:

(2) There must be means for inspecting the critical parts of each exchanger;

(3) Each exchanger must have cooling provisions wherever it is subject to contact with exhaust gases; and

(4) Each exhaust heat exchanger muff may have stagnant areas or liquid traps that would increase the probability of ignition of flammable fluids or vapors that might be present in case of the failure or malfunction of components carrying flammable fluids.

POWERPLANT CONTROLS AND ACCESSORIES

§ 29.1141 Powerplant controls: General.

(a) Powerplant controls must be located and arranged under § 29.777 and marked under § 29.1555.

(b) Each control must be located so that it cannot be inadvertently operated by persons entering, leaving, or moving normally in the cockpit.

(c) Each flexible powerplant control must be approved.

(d) Each control must be able to maintain any set position without—

(1) Constant attention; or

(2) Tendency to creep due to control loads or vibration.

(e) Each control must be able to withstand operating loads without excessive deflection.

(f) Controls of powerplant valves required for safety must have—

(1) For manual valves, positive stops or in the case of fuel valves suitable index provisions, in the open and closed position; and

(2) For power-assisted valves, a means to indicate to the flight crew when the valve—

(i) Is in the fully open or fully closed position; or

(ii) Is moving between the fully open and fully closed position.

[(Amdt. 29–13, Eff. 5/2/77); (Amdt. 29–26, Eff. 10/3/88)]

§ 29.1142 Auxiliary power unit controls.

Means must be provided on the flight deck for starting, stopping, and emergency shutdown of each installed auxiliary power unit.

[(Amdt. 29–17, Eff. 12/1/78)]

§ 29.1143 Engine controls.

(a) There must be a separate power control for each engine.

control. However, the injection system pump may have a separate control.

(e) if a power control incorporates a fuel shutoff feature, the control must have a means to prevent the inadvertent movement of the control into the shutoff position. The means must—

(1) Have a positive lock or stop at the idle position; and

(2) Require a separate and distinct operation to place the control in the shutoff position.

[(f) For rotorcraft to be certificated for a 30-second OEI power rating, a means must be provided to automatically activate and control the 30-second OEI power and prevent any engine from exceeding the installed engine limits associated with the 30-second OEI power rating approved for the rotorcraft.]

(Amdt. 29–12, Eff. 2/1/77); (Amdt. 29–26, Eff. 10/3/88); [(Amdt. 29–34, Eff. 10/17/94)]

§ 29.1145 Ignition switches.

(a) Ignition switches must control each ignition circuit on each engine.

(b) There must be means to quickly shut off all ignition by the grouping of switches or by a master ignition control.

(c) Each group of ignition switches, except ignition switches for turbine engines with continuous ignition is not required, and each master ignition control must have a means to prevent its inadvertent operation.

[(Amdt. 29–13, Eff. 5/2/77)]

§ 29.1147 Mixture controls.

(a) If there are mixture controls, each engine must have a separate control, and the controls must be arranged to allow—

(1) Separate control of each engine; and

(2) Simultaneous control of all engines.

(b) Each intermediate position of the mixture controls that corresponds to a normal operating setting must be identifiable by feel and sight.

There must be a separate carburetor air temperature control for each engine.

§ 29.1159 Supercharger controls.

Each supercharger control must be accessible to—

(a) The pilots; or

(b) (If there is a separate flight engineer station with a control panel) the flight engineer.

§ 29.1163 Powerplant accessories.

(a) Each engine mounted accessory must—

(1) Be approved for mounting on the engine involved;

(2) Use the provisions on the engine for mounting; and

(3) Be sealed in such a way as to prevent contamination of the engine oil system and the accessory system.

(b) Electrical equipment subject to arcing or sparking must be installed to minimize the probability of igniting flammable fluids or vapors.

(c) If continued rotation of an engine-driven cabin supercharger or any remote accessory driven by the engine will be a hazard if they malfunction, there must be means to prevent their hazardous rotation without interfering with the continued operation of the engine.

(d) Unless other means are provided, torque limiting means must be provided for accessory drives located on any component of the transmission and rotor drive system to prevent damage to these components from excessive accessory load.

[(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–22, Eff. 3/26/84); (Amdt. 29–26, Eff. 10/3/88)]

§ 29.1165 Engine ignition systems.

(a) Each battery ignition system must be supplemented with a generator that is automatically available as an alternate source of electrical energy to allow continued engine operation if any battery becomes depleted.

tery with the generator running at its normal operating speed; and

(3) The condition of a completely depleted battery with the generator operating at idling speed, if there is only one battery.

(d) Magneto ground wiring (for separate ignition circuits) that lies on the engine side of any firewall must be installed, located, or protected to minimize the probability of the simultaneous failure of two or more wires as a result of mechanical damage, electrical fault, or other cause.

(e) No ground wire for any engine may be routed through a fire zone of another engine unless each part of that wire within that zone is fireproof.

(f) Each ignition system must be independent of any electrical circuit that is not used for assisting, controlling, or analyzing the operation of that system.

(g) There must be means to warn appropriate crewmembers if the malfunctioning of any part of the electrical system is causing the continuous discharge of any battery necessary for engine ignition.

[(Amdt. 29–12, Eff. 2/1/77)]

POWERPLANT FIRE PROTECTION

§ 29.1181 Designated fire zones: Regions included.

(a) Designated fire zones are—

(1) The engine power section of reciprocating engines;

(2) The engine accessory section of reciprocating engines;

(3) Any complete powerplant compartment in which there is no isolation between the engine power section and the engine accessory section, for reciprocating engines;

(4) Any auxiliary power unit compartment;

(5) Any fuel-burning heater and other combustion equipment installation described in § 29.859;

(6) The compressor and accessory sections of turbine engines; and

(7) The combustor, turbine, and tailpipe sections of turbine engine installations except sec-

§ 29.1183 Lines, fittings, and components.

(a) Except as provided in paragraph (b) of this section, each line, fitting, and other component carrying flammable fluid in any area subject to engine fire conditions and each component which conveys or contains flammable fluid in a designated fire zone must be fire resistant, except that flammable fluid tanks and supports in a designated fire zone must be fireproof or be enclosed by a fireproof shield unless damage by fire to any non-fireproof part will not cause leakage or spillage of flammable fluid. Components must be shielded or located so as to safeguard against the ignition of leaking flammable fluid. An integral oil sump of less than 25-quart capacity on a reciprocating engine need not be fireproof nor be enclosed by a fireproof shield.

(b) Paragraph (a) of this section does not apply to—

(1) Lines, fittings, and components which are already approved as part of a type certificated engine; and

(2) Vent and drain lines, and their fittings, whose failure will not result in or add to, a fire hazard.

[(Amdt. 29–2, Eff. 6/4/67); (Amdt. 29–10, Eff. 10/31/74); (Amdt. 29–22, Eff. 3/26/84)]

§ 29.1185 Flammable fluids.

(a) No tank or reservoir that is part of a system containing flammable fluids or gases may be in a designated fire zone unless the fluid contained, the design of the system, the materials used in the tank and its supports, the shutoff means, and the connections, lines, and controls provide a degree of safety equal to that which would exist if the tank or reservoir were outside such a zone.

(b) Each fuel tank must be isolated from the engines by a firewall or shroud.

(c) There must be at least one-half inch of clear airspace between each tank or reservoir and each firewall or shroud isolating a designated fire zone, unless equivalent means are used to prevent heat transfer from the fire zone to the flammable fluid.

component containing flammable fluids. The drainage means must be—

(1) Effective under conditions expected to prevail when drainage is needed; and

(2) Arranged so that no discharged fluid will cause an additional fire hazard.

(b) Each designated fire zone must be ventilated to prevent the accumulation of flammable vapors.

(c) No ventilation opening may be where it would allow the entry of flammable fluids, vapors, or flame from other zones.

(d) Ventilation means must be arranged so that no discharged vapors will cause an additional fire hazard.

(e) For category A rotorcraft, there must be means to allow the crew to shut off the sources of forced ventilation in any fire zone (other than the engine power section of the powerplant compartment) unless the amount of extinguishing agent and the rate of discharge are based on the maximum airflow through that zone.

§ 29.1189 Shutoff means.

(a) There must be means to shut off or otherwise prevent hazardous quantities of fuel, oil, de-icing fluid, and other flammable fluids from flowing into, within, or through any designated fire zone, except that this means need not be provided—

(1) For lines, fittings, and components forming an integral part of an engine;

(2) For oil systems for turbine engine installations in which all components of the oil system, including oil tanks, are fireproof or located in areas not subject to engine fire conditions; or

(3) For engine oil systems in category B rotorcraft using reciprocating engines of less than 500 cubic inches displacement.

(b) The closing of any fuel shutoff valve for any engine may not make fuel unavailable to the remaining engines.

(c) For category A rotorcraft, no hazardous quantity of flammable fluid may drain into any designated fire zone after shutoff has been accomplished, nor may the closing of any fuel shutoff valve for any engine make fuel unavailable to the remaining engines while drained into a designated fire zone.

(f) Except for ground-use-only auxiliary power unit installations, there must be means to prevent inadvertent operation of each shutoff and to make it possible to reopen it in flight after it has been closed.

[(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–12, Eff. 2/1/77); (Amdt. 29–22, Eff. 3/26/84)]

§ 29.1191 Firewalls.

(a) Each engine, including the conbustor, turbine, and tailpipe sections of turbine engine installations, must be isolated by a firewall, shroud, or equivalent means, from personnel compartments, structures, controls, rotor mechanisms, and other parts that are—

(1) Essential to controlled flight and landing; and

(2) Not protected under § 29.861.

(b) Each auxiliary power unit, combustion heater, and other combustion equipment to be used in flight, must be isolated from the rest of the rotorcraft by firewalls, shrouds, or equivalent means.

(c) Each firewall or shroud must be constructed so that no hazardous quantity of air, fluid, or flame can pass from any engine compartment to other parts of the rotorcraft.

(d) Each opening in the firewall or shroud must be sealed with close-fitting fireproof grommets, bushings, or firewall fittings.

(e) Each firewall and shroud must be fireproof and protected against corrosion.

(f) In meeting this section, account must be taken of the probable path of a fire as affected by the airflow in normal flight and in autorotation.

[(Amdt. 29–3, Eff. 2/25/68)]

§ 29.1193 Cowling and engine compartment covering.

(a) Each cowling and engine compartment covering must be constructed and supported so that it can resist the vibration, inertia, and air loads to which it may be subjected in operation.

(d) Each part of the cowling or engine compartment covering subject to high temperatures due to its nearness to exhaust system parts or exhaust gas impingement must be fireproof.

(e) Each rotorcraft must—

(1) Be designed and constructed so that no fire originating in any fire zone can enter, either through openings or by burning through external skin, any other zone or region where it would create additional hazards;

(2) Meet the requirements of paragraph (e)(1) of this section with the landing gear retracted (if applicable); and

(3) Have fireproof skin in areas subject to flame if a fire starts in or burns out of any designated fire zone.

(f) A means of retention for each openable or readily removable panel, cowling, or engine or rotor drive system covering must be provided to preclude hazardous damage to rotors or critical control components in the event of—

(1) Structural or mechanical failure of the normal retention means, unless such failure is extremely improbable; or

(2) Fire in a fire zone, if such fire could adversely affect the normal means of retention.

[(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–13, Eff. 5/2/77); (Amdt. 29–26, Eff. 10/3/88)]

§ 29.1194 Other surfaces.

All surfaces aft of, and near, engine compartments and designated fire zones, other than tail surfaces not subject to heat flames, or sparks emanating from a designated fire zone or engine compartment, must be at least fire resistant.

[(Amdt. 29–3, Eff. 2/25/68)]

§ 29.1195 Fire extinguishing systems.

(a) Each turbine engine powered rotorcraft and Category A reciprocating engine powered rotorcraft, and each Category B reciprocating engine powered rotorcraft with engines of more than 1,500 cubic inches must have a fire extinguishing system for the designated fire zones. The fire extinguishing

(2) For each other designated fire zone, provide two adequate discharges.

(c) For single engine rotorcraft, the quantity of extinguishing agent and the rate of discharge must provide at least one adequate discharge for the engine compartment.

(d) It must be shown by either actual or simulated flight tests that under critical airflow conditions in flight the discharge of the extinguishing agent in each designated fire zone will provide an agent concentration capable of extinguishing fires in that zone and of minimizing the probability of reignition.

[(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–13, Eff. 5/2/77); (Amdt. 29–17, Eff. 12/1/78)]

§ 29.1197 Fire extinguishing agents.

(a) Fire extinguishing agents must—

(1) Be capable of extinguishing flames emanating from any burning of fluids or other combustible materials in the area protected by the fire extinguishing system; and

(2) Have thermal stability over the temperature range likely to be experienced in the compartment in which they are stored.

(b) If any toxic extinguishing agent is used it must be shown by test that entry of harmful concentrations of fluid or fluid vapors into any personnel compartment (due to leakage during normal operation of the rotorcraft, or discharge on the ground or in flight) is prevented, even though a defect may exist in the extinguishing system.

(c) [Deleted]

[(Amdt. 29–12, Eff. 2/1/77); (Amdt. 29–13, Eff. 5/2/77)]

§ 29.1199 Extinguishing agent containers.

(a) Each extinguishing agent container must have a pressure relief to prevent bursting of the container by excessive internal pressures.

(b) The discharge end of each discharge line from a pressure relief connection must be located so that discharge of the fire extinguishing agent would not damage the rotorcraft. The line must

(1) Falling below that necessary to provide an adequate rate of discharge; or

(2) Rising high enough to cause premature discharge.

[(Amdt. 29–13, Eff. 5/2/77)]

§ 29.1201 Fire extinguishing system materials.

(a) No materials in any fire extinguishing system may react chemically with any extinguishing agent so as to create a hazard.

(b) Each system component in an engine compartment must be fireproof.

§ 29.1203 Fire detector systems.

(a) For each turbine engine powered rotorcraft and category A reciprocating engine powered rotorcraft, and for each category B reciprocating engine powered rotorcraft with engines of more than 900

ation.

(c) No fire detector may be affected by any oil, water, other fluids, or fumes that might be present.

(d) There must be means to allow crewmembers to check, in flight, the functioning of each fire detector system electrical circuit.

(e) The wiring and other components of each fire detector system in an engine compartment must be at least fire resistant.

(f) No fire detector system component for any fire zone may pass through another fire zone, unless—

(1) It is protected against the possibility of false warnings resulting from fires in zones through which it passes; or

(2) The zones involved are simultaneously protected by the same detector and extinguishing systems.

[(Amdt. 29–3, Eff. 2/25/68)]